May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 1

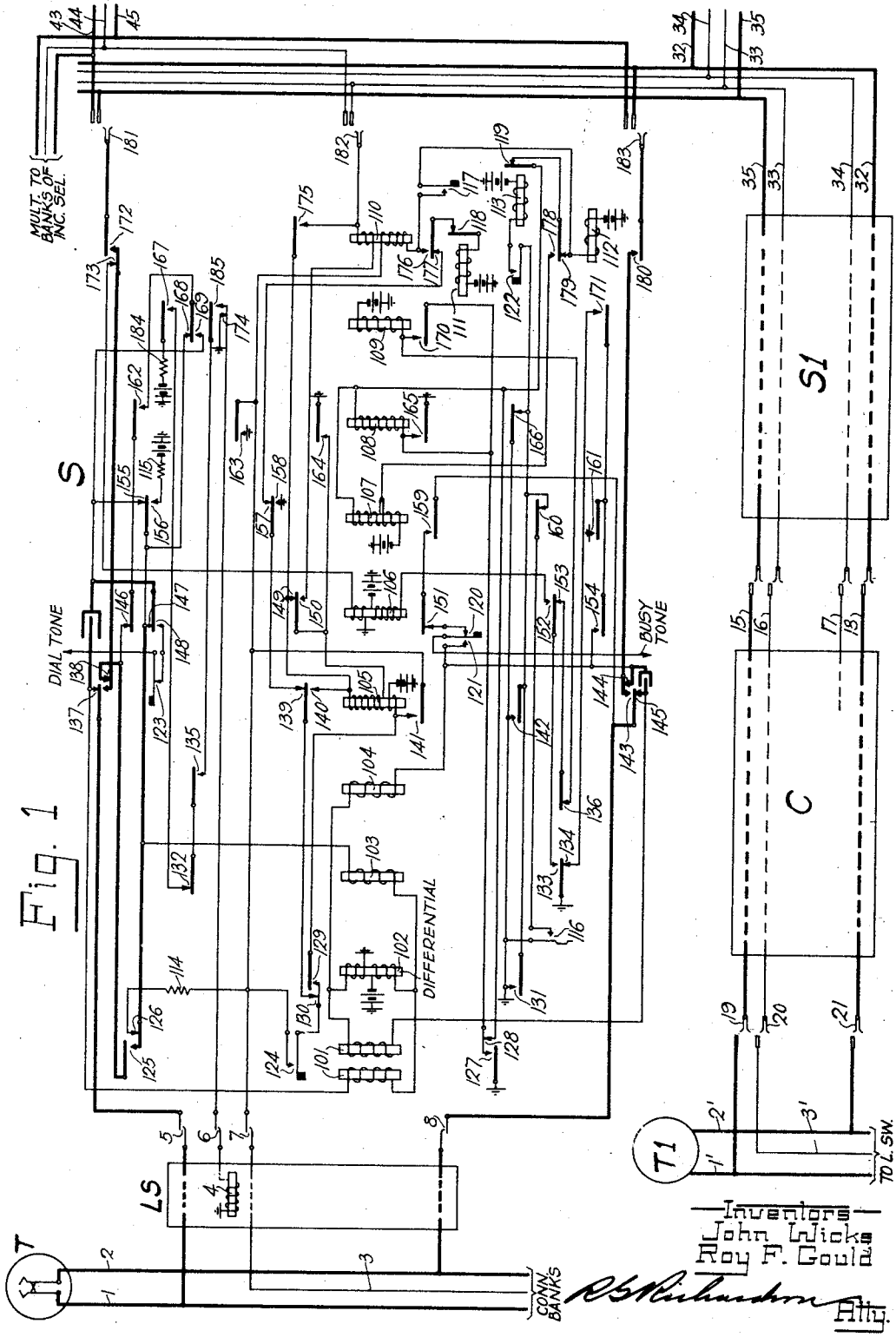


Fig. 1

Inventors
John Wicks
Roy F. Gould

Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 2

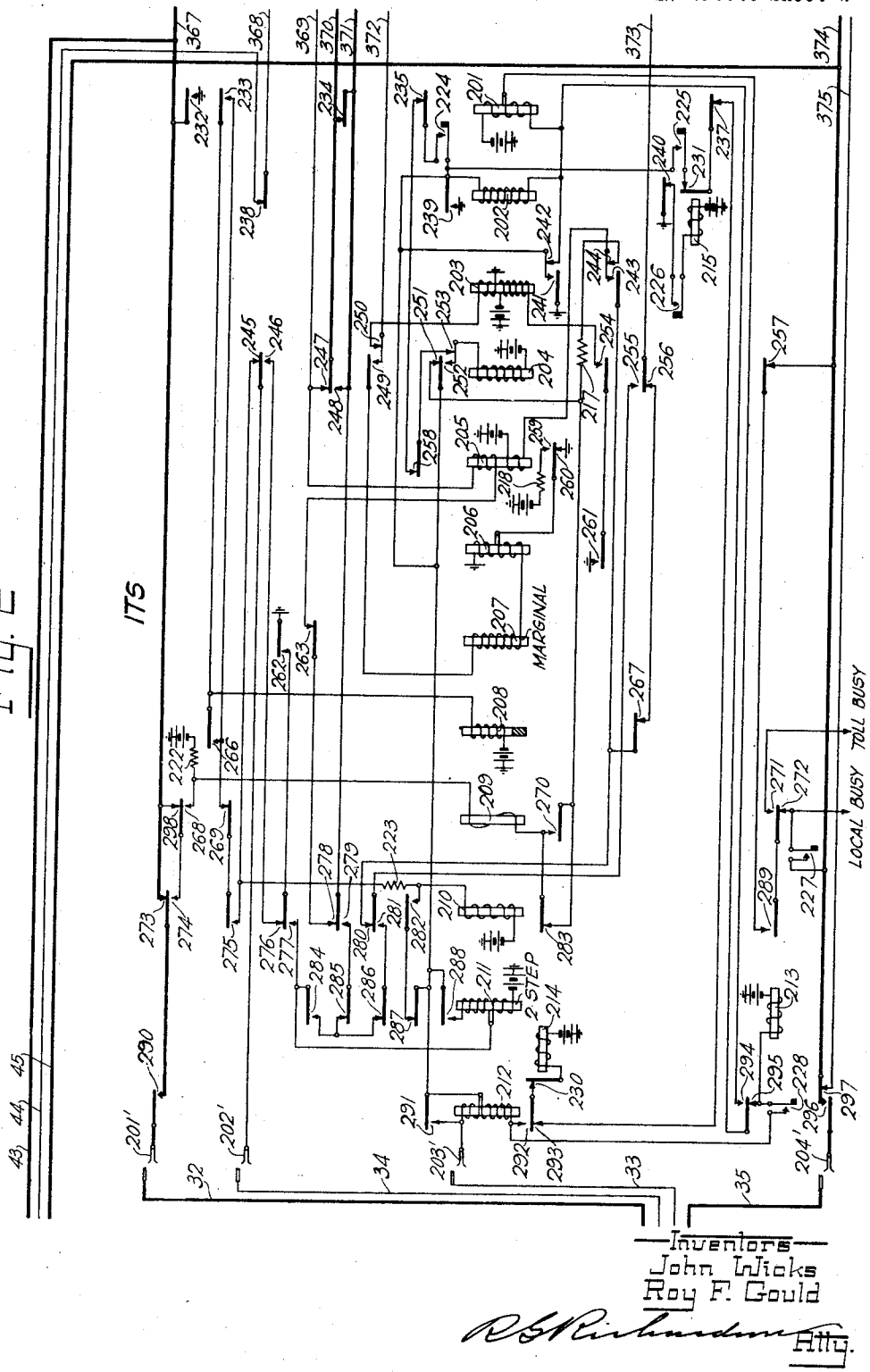


Fig. 2

Inventors
John Wicks
Roy F. Gould

R. G. Richardson
Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 3

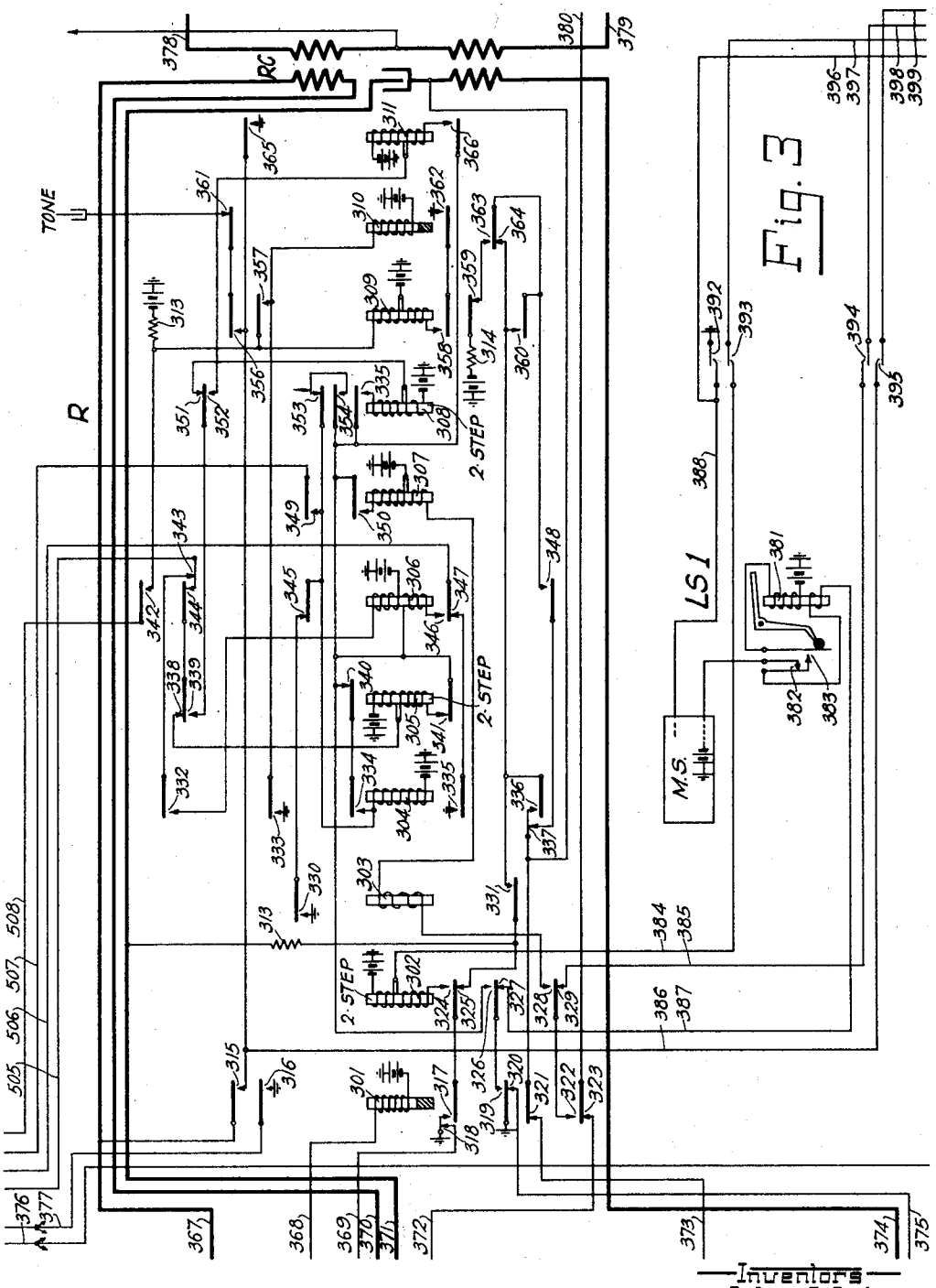


Fig. 3

Inventors
John Wicks
Roy F. Gould

R. B. Richardson Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 4

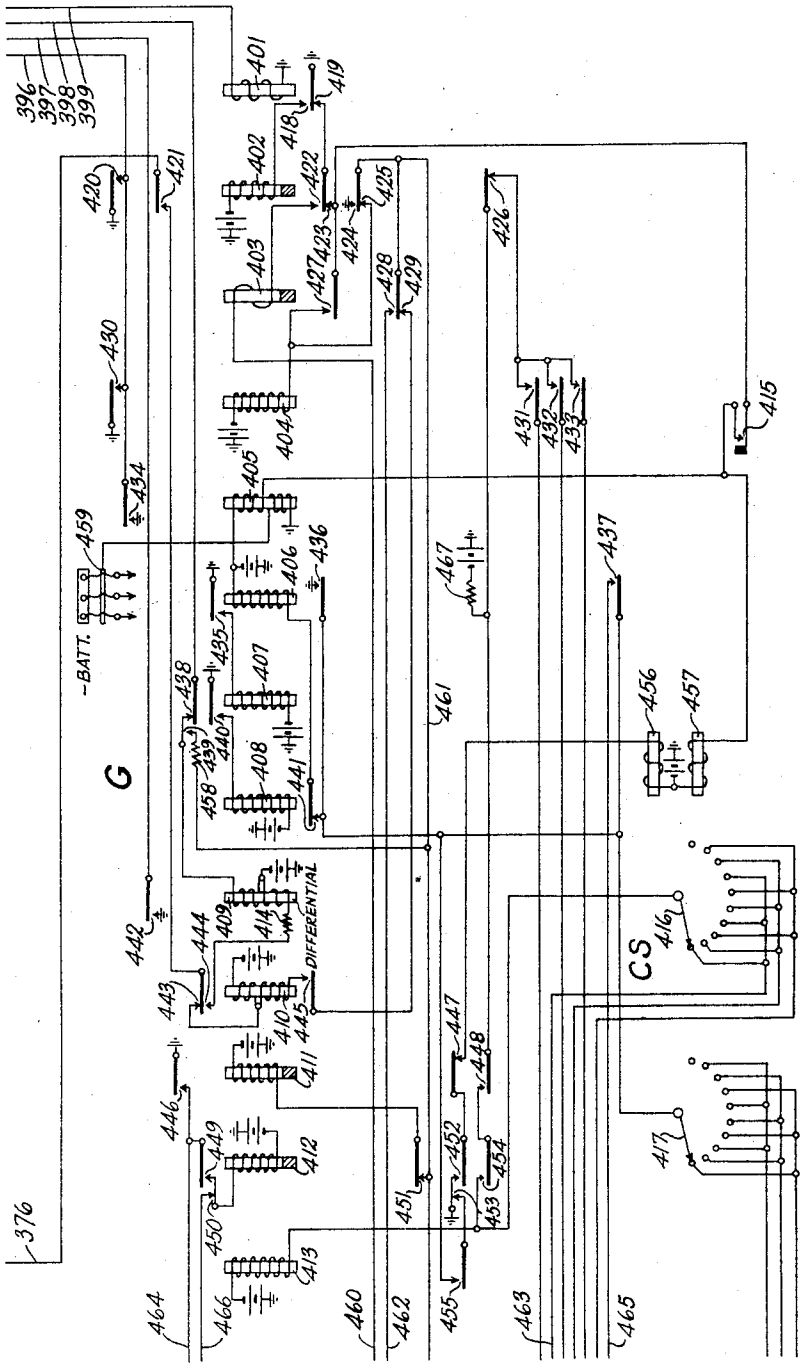


Fig. 4 part 1

Inventors
John Wicks
Roy F Gould
R. C. Richardson
Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 5

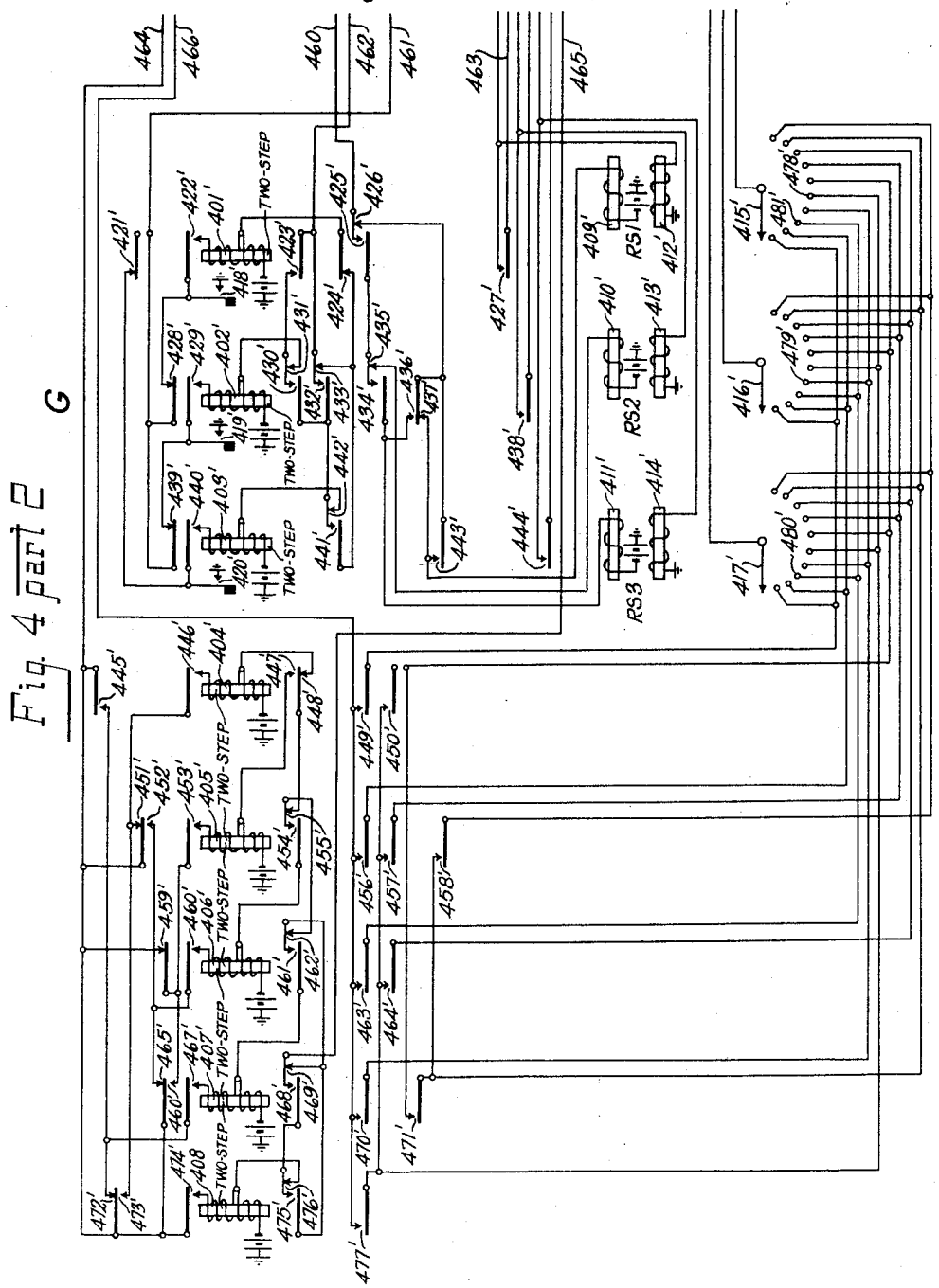


Fig. 4 part 2

Inventors
John J. Wicks
Roy F. Gould
R. B. Richardson Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 6

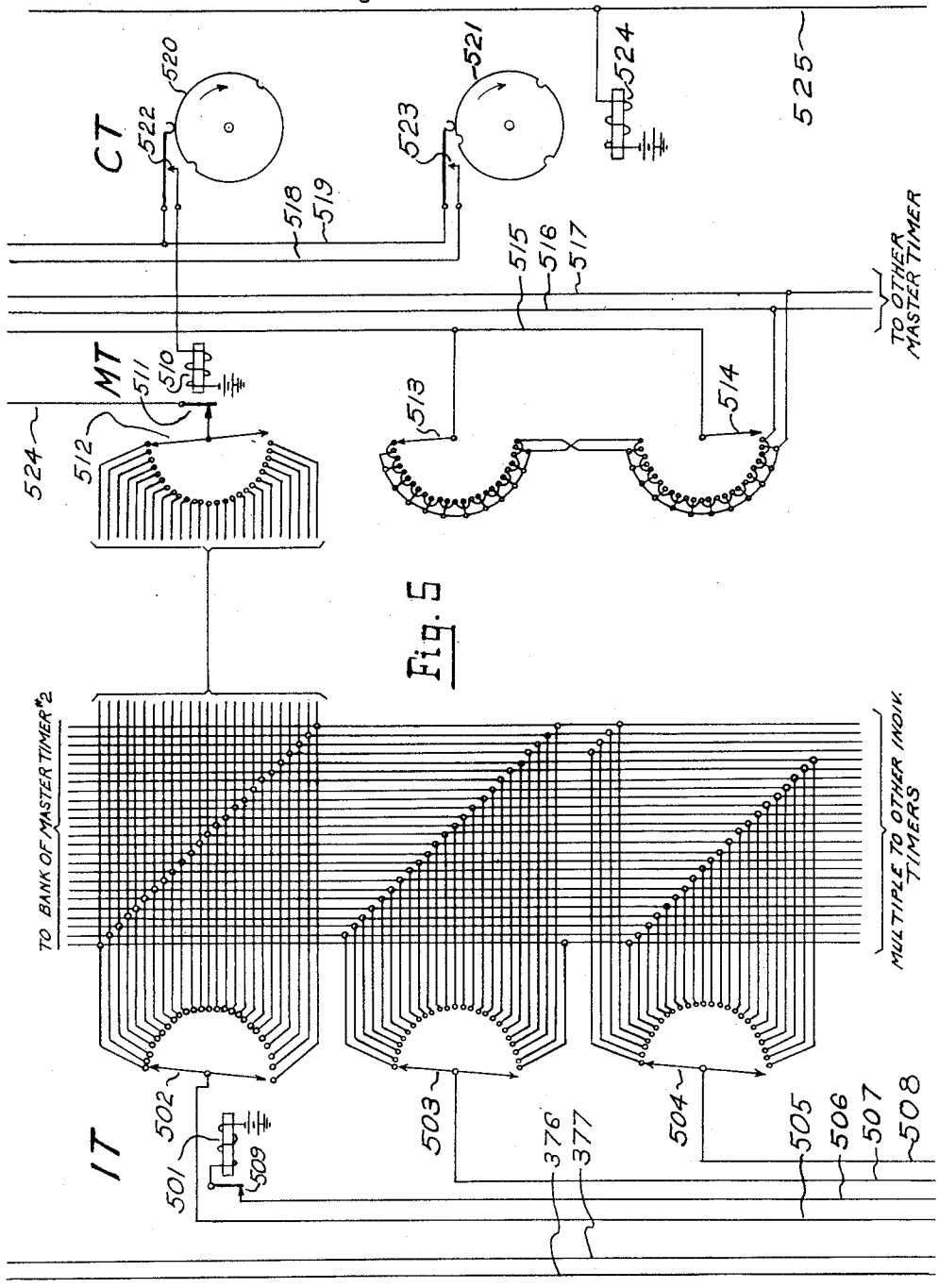


Fig. 5

Inventors
John Wicks
Roy F. Gould

R. G. Richardson
Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 7

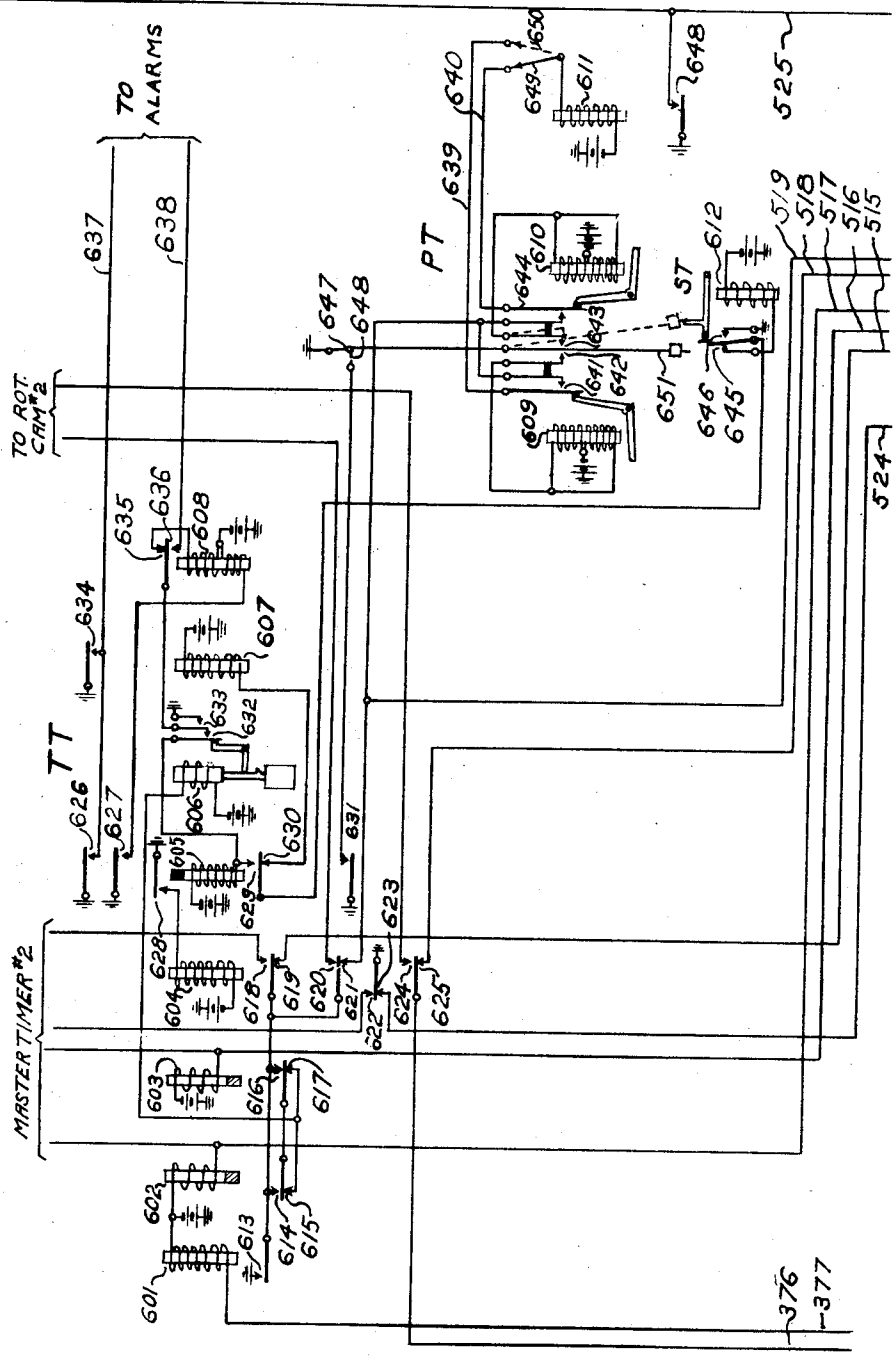


Fig. 6

Inventors
John Wicks
Roy F. Gould

Attorney.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 8

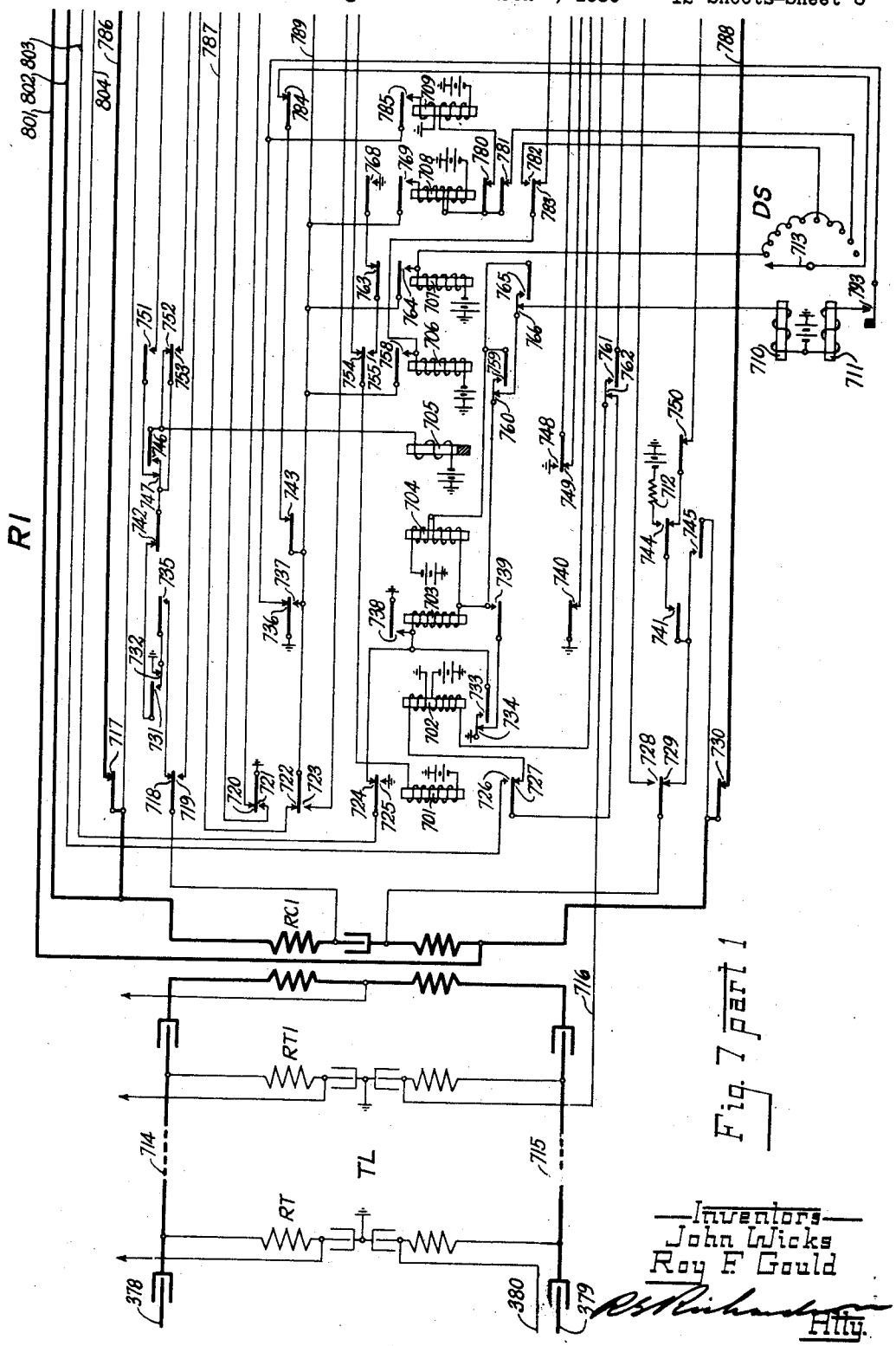


Fig. 7 part 1

Inventors
John Wicks
Roy F Gould
By R S Richardson
Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 9

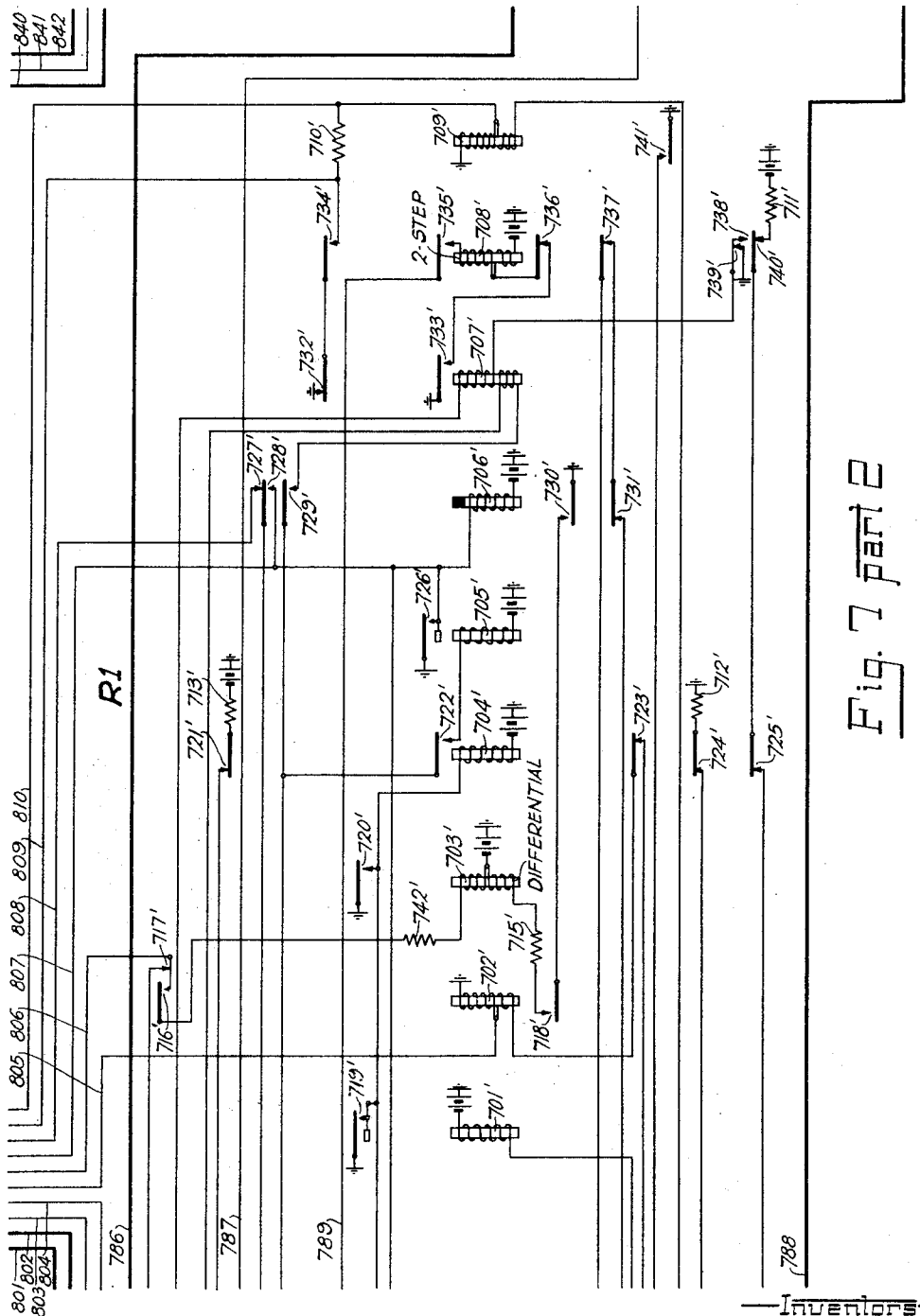


Fig. 7 part 2

Inventors
John Wicks
Roy F. Gould

Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 10

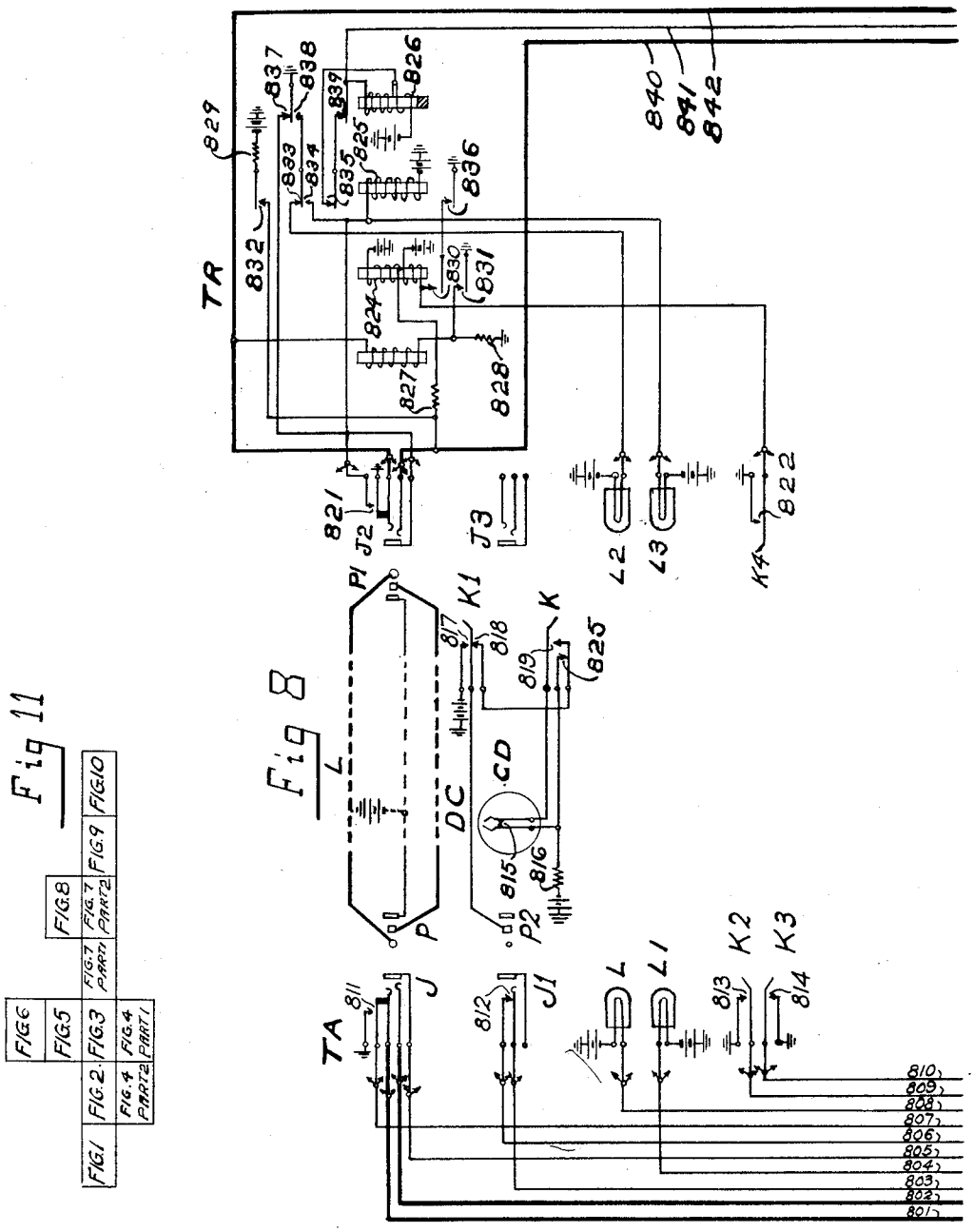


Fig 8

Fig 11

FIG 6	FIG 5	FIG 3	FIG 4 PART 1	FIG 7 PART 1	FIG 9
FIG 1	FIG 2	FIG 4 PART 2	FIG 7 PART 2	FIG 8	FIG 10

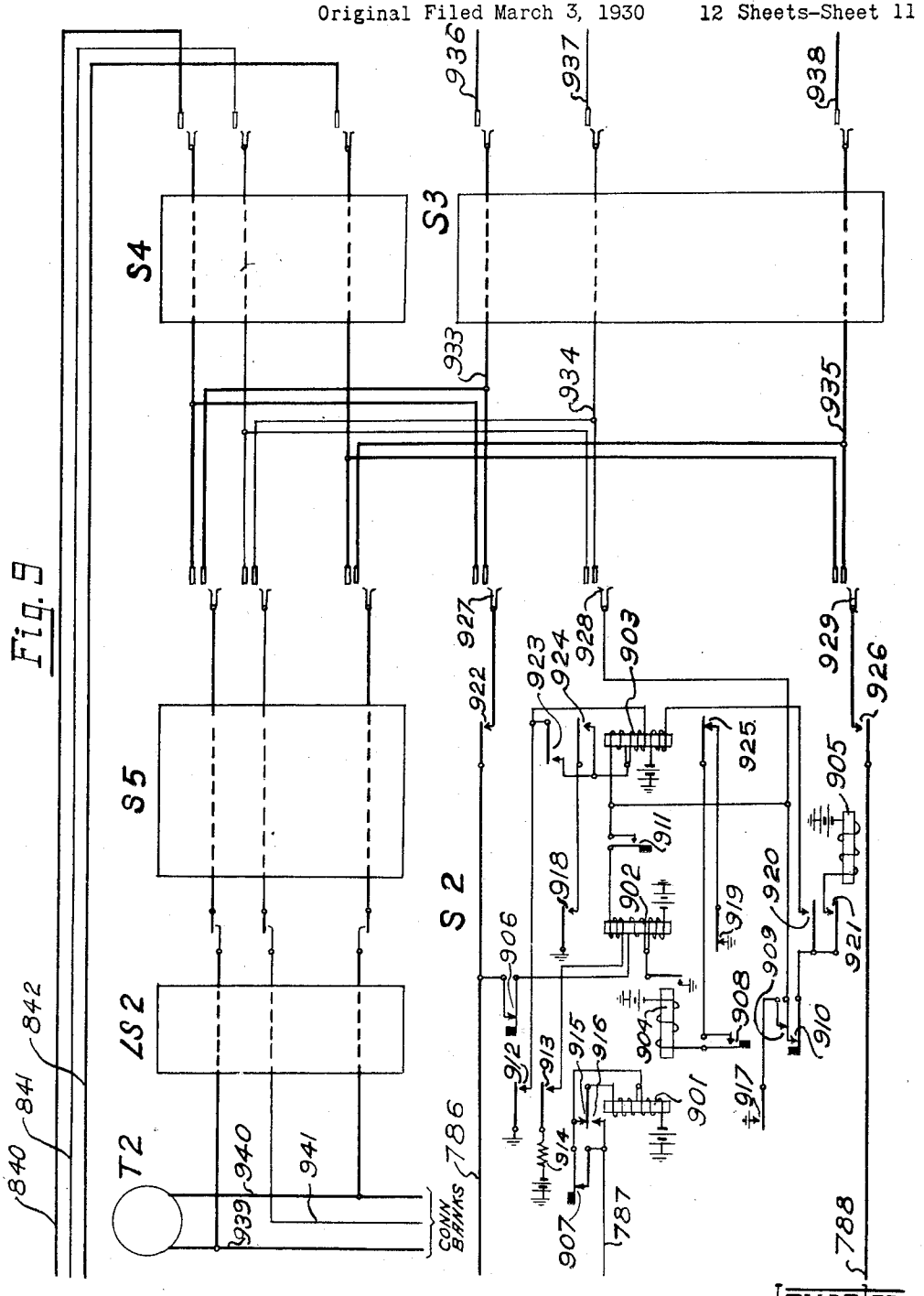
Inventors
John Wicks
Roy F. Gould

R. B. Richardson Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 11



Inventors—
John Wicks
Roy F. Gould

R. B. Richardson Atty.

May 16, 1933. J. WICKS ET AL 1,909,082

MULTIOFFICE TELEPHONE SYSTEM

Original Filed March 3, 1930 12 Sheets-Sheet 12

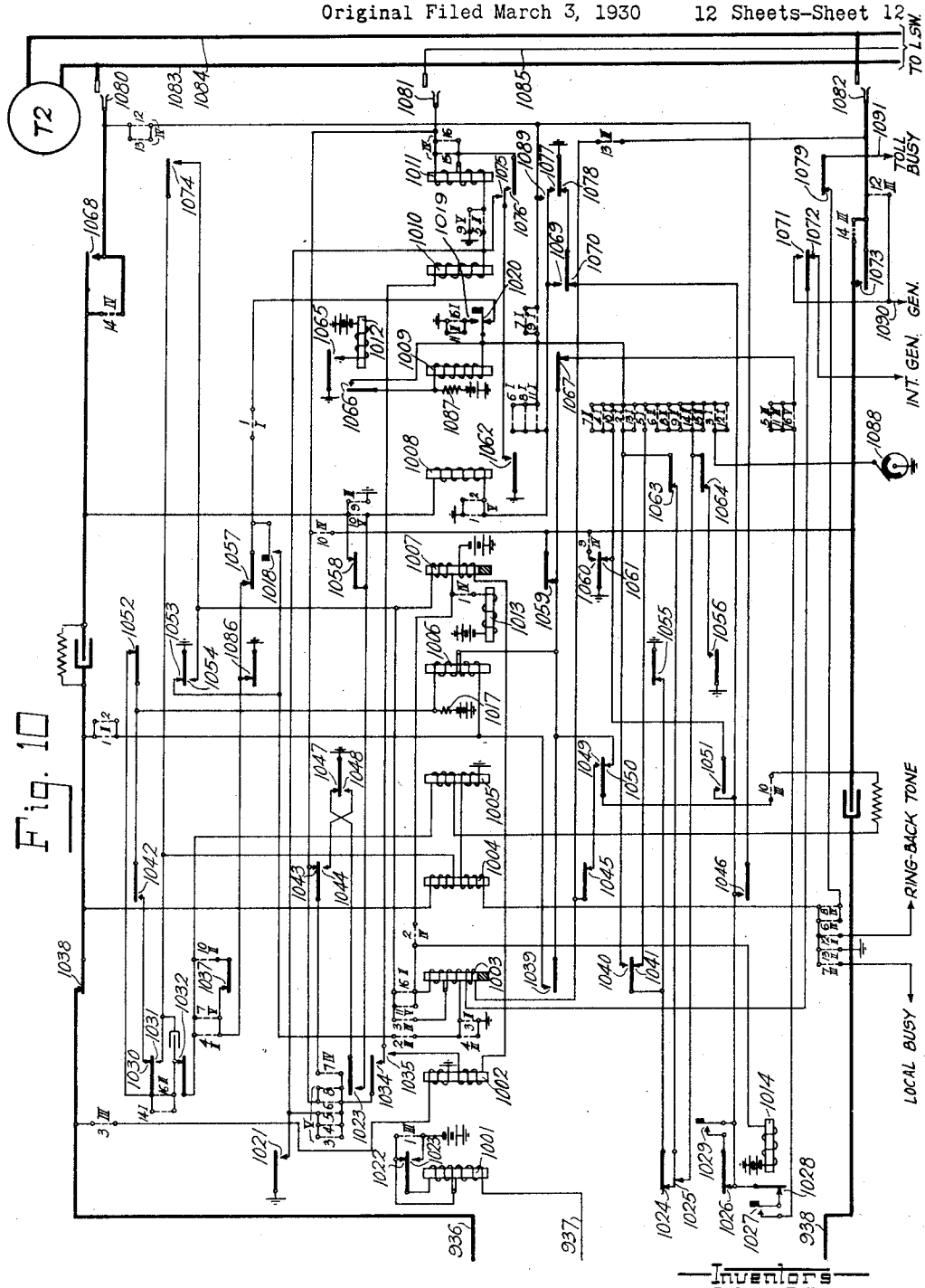


Fig. 10

Inventors
John Wicks
Roy F. Gould

Atty.

Patented May 16, 1933 1,909,082

UNITED STATES PATENT OFFICE

JOHN WICKS, OF OAK PARK, AND ROY F. GOULD, OF CHICAGO, ILLINOIS, ASSIGNORS, BY MESNE ASSIGNMENTS, TO ASSOCIATED ELECTRIC LABORATORIES, INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE

MULTIOFFICE TELEPHONE SYSTEM

Application filed March 3, 1930, Serial No. 432,688. Renewed June 27, 1932.

This invention relates in general to multioffice telephone systems, particularly to multioffice automatic telephone systems in which the switching apparatus employed in one or more offices is operated according to a method of control different from that of the switching apparatus employed in other offices of the system. The object of the invention, broadly stated, is the provision of new and improved circuits and apparatus for supplying local and toll service as well as various auxiliary services in systems of the above type.

The invention is particularly adapted for systems of the so-called "inverted" type in which talking and operating current is fed from the first switch of the train instead of from the last switch. A system of this type employing the loop method of control is shown in the co-pending application of J. Wicks, Serial No. 395,882, filed September 28, 1929. A system of the type employing the single conductor method of control, that is, in which current impulses are transmitted ahead over only one conductor of the local trunks is described in Die Fernsprechanlagen mit Wahler-Betrieb by Lubberger, second edition, 1924, and representative circuits are shown in the supplement, pages 44–48.

Both of the above systems are well known and are used commercially. In certain instances it has been found advisable to employ apparatus of both systems in a single multioffice network, in which case it is necessary to provide special interconnecting facilities. The problem of providing such facilities is complicated by the necessity of supplying various auxiliary services such as time and zone metering and preferred toll and trunk services. Further complications arise from the fact that the switches of the two systems are normally adjusted to operate on a slightly different pulse ratio or length of impulse. While the difference is not great, it narrows the operating range of the switches and may readily become a source of trouble when the directive impulses are transmitted over relatively long trunk lines, or are repeated through several tandem offices. This operating characteristic must be taken into consideration if efficient and reliable operation is to be maintained.

One of the features of the invention is the arrangement for supplying preferred service on trunk calls without necessitating any operation by the calling subscriber other than the dialling of the wanted subscriber's telephone number. By this arrangement, when a trunk call is extended to a subscriber who is engaged in a local connection, both the calling and the called subscribers are given a preliminary warning tone after which the local connection is released and the trunk connection established. A somewhat similar service has been supplied in the past in connection with toll operation, that is, the toll operator by ringing or by dialling an additional digit has been able to cut-in on a local connection and establish the preferred call. In so far as applicant is aware, this type of service has not previously been extended to subscriber control trunk calls or handled on an automatic basis.

Another feature of the invention is the arrangement for regenerating the directive impulses on calls between offices of different types in order to prevent faulty operation due to impulse distortion or differing pulse ratio.

A further feature is the arrangement for metering trunk and toll calls, including improved timing switches and arrangements for automatically cutting an auxiliary timing apparatus into service in case of failure of the regular apparatus.

A still further feature is the arrangement for switching calls to an operator's position and releasing the exchange switching apparatus.

The foregoing features together with others not specifically mentioned at this time will be further discussed in connection with the detailed description of the operation of the various circuits.

The accompanying drawings comprising Figs. 1 to 11, inclusive, show by means of the usual circuit diagrams a sufficient amount of equipment in a system embodying the invention to permit the invention to be readily described and understood. Only such switch-

ing apparatus as is directly concerned with the invention has been shown in detail in order to avoid unnecessarily complicating the description. This apparatus is assumed to be located in two offices of a multi-office network, the offices employing, respectively, the two types of apparatus previously referred to. It is to be understood, however, that this particular embodiment of the invention is shown only for convenience of description.

Referring now to the drawings. In Fig. 1 is shown an automatic substation T whose associated line terminates in a lineswitch LS and is accessible in the banks of connectors, such as the connector C. Lineswitch LS is one of a group of similar switches terminating subscriber's lines and having access to a group of trunks extending to selectors, such as selector S. The lineswitch which is shown only in skeleton form may be of any suitable type, or, if used, line finders may be used. Selector S is of the type adapted to feed battery to both calling and called subscribers and to repeat impulses to the other switches of the train. This selector is arranged to absorb one or more digits in order that a uniform numbering scheme may be used throughout the system, but this particular feature is not concerned with the invention. Selector S and other corresponding selectors have access to local trunks and outgoing trunks. The local trunks terminate in intermediate selectors, such as the selector S1, and the outgoing trunks terminate in repeaters, such as the repeater R, (Fig. 3) which will be described in later paragraphs. Selector S1 may be similar to the intermediate selector disclosed in Wicks Patent No. 1,778,204, granted Oct. 14, 1930, modified however by addition of a fourth wiper for purposes which will be discussed hereinafter. Selector S1 and corresponding selectors have access to combination toll and local connectors C which in turn have access to subscribers' lines, such as the one extending to substation T1. Connector C is arranged to operate as a local connector when seized by a calling local subscriber and as a toll connector when seized in a toll call. This connector may be the same as the combination toll and local connector disclosed in the previously referred to Wicks application, Serial No. 395,882. Substation T1 will be similar in all respects to substation T, and will have an associated lineswitch corresponding to lineswitch LS.

Fig. 2 shows an incoming toll selector ITS associated with a two-way inter-office trunk. This trunk which terminates in one exchange in the repeater R is accessible to local selectors, such as S, for extending calls to the other exchange. Selector ITS is operated on incoming calls over the trunk and has access to subscribers in the exchange by way of intermediate selectors, such as selector S1, and connectors, such as connector C.

Fig. 3 shows a repeater R terminating one end of the two-way trunk line TL extending to a distant office. Associated with this repeater are the incoming selector ITS previously referred to, lineswitch LS1, and an individual timing switch IT. Lineswitch LS1 serves to connect up an idle regenerating repeater G (Fig. 4), and timing switch IT controls the elapsed time metering as will be described hereinafter.

In Fig. 4, parts 1 and 2, there is shown an impulse regenerating repeater or register sender switch which is adapted to be associated temporarily with a repeater, such as repeater R. On outgoing calls over the trunk the dialled impulses are registered in this repeater which in turn retransmits corresponding impulses of the proper type to operate the switches at the distant end of the trunk. The switch consists essentially of a relay distributor, a group of pulsing relays, a control switch CS, and a group of register switches RS1, RS2 and RS3.

In Fig. 5 is shown the individual timing switch IT associated with a repeater R. This timing switch together with other similar switches associated with other repeaters have access to a common bank multiple together with the master timer MT. CT is a cam timer associated wth master timer MT and its function is to supply pulses of the proper frequency to operate the master timer.

Fig. 6 shows a pendulum timer PT and a timer transfer circuit TT. The pendulum timer is associated with and individual to the cam timer CT and controls the operation thereof. The master timer, cam timer, and pendulum timer are common to all individual timing switches of the exchange. Inasmuch as this common equipment has a very important function to perform, it is desirable to provide a duplicate set to be used in case of failure of one or more of the common switches. The transfer circuit TT is arranged to switch over and connect up the auxiliary timing set in case of such trouble. The auxiliary apparatus is similar in all respects to that shown with the exception of the mechanical starting device associated with the pendulum timer of the auxiliary apparatus.

Fig. 7, parts 1 and 2, show a repeater R1 associated with the other end of the trunk line TL. Two branches extend from the repeater, one terminating in a selector, such as the selector S2, and the other terminating at a manual position or toll board, Fig. 8. The discriminating switch DS associated with the repeater responds to certain of the digits dialled over the trunk and controls the branch over which the call is to be extended.

In Fig. 8 there are shown various circuits located at the manual position or toll board,

including the trunk apparatus TA terminating the trunk incoming from repeater R1, the trunk relays TR in which a selector level trunk terminates and the toll line jack J3 terminating a trunk line extending to another office of the same or another system. The cord circuit or link L may be of any well known type suitable for interconnecting the various trunks and is shown only in skeleton form. The dialling cord DC is adapted to be associated with the trunk extending to repeater R1 for controlling the switches at the exchange terminating the other end of the trunk line TL. It is to be understood that in practice there will be a plurality of the various trunk lines as well as link circuits at the toll board. There will ordinarily be one dialling cord common to the position.

In Fig. 9, T2 represents an ordinary automatic substation whose associated line terminates in lineswitch LS2 which may be similar to lineswitch LS previously described or may be any well known type of lineswitch or line finder. The lineswitch has access to local first selector S5 which is of the general type described in the previously referred to Lubberger book. The first selectors have access to various groups of intermediate selectors represented respectively by the selectors S3 and S4. Selectors S4 have access to local connectors (not shown) and to trunks extending to the toll board, such as the trunk terminating in relay group TR. Selectors S3 and S4 may be similar in all respects to selector S2. Selector S2 incidentally is directly associated with repeater R1 and has access to the intermediate selectors in common with selector S5. The intermediate selectors have access to the connectors as previously mentioned, the group represented by selector S3 having access to combination connectors, such as connector C1 (Fig. 10).

In Fig. 10 is shown a combination toll and local connector C1 which has access to regular subscribers' lines to the exchange of which one line terminating in substation T3 is shown.

Fig. 11 is a layout diagram showing how the various sheets of drawings should be arranged in order to be best understood.

From the foregoing description it will be obvious that the apparatus shown in Figs. 1 to 6, inclusive, is located in one exchange while that shown in Figs. 7 to 10, inclusive, is located in another exchange. It may be further noted that the apparatus located in the first exchange is operated according to the loop method of control while that located in the second exchange is operated according to the single conductor method of control. These offices will be identified in later paragraphs by referring to them, respectively, as the first and second exchanges or offices.

Having described the various units of apparatus and their interrelation, the operations involved in setting up various connections in the system will now be described briefly.

Local calls in the first exchange do not involve any of the features of the invention. A call from substation T to substation T1 is extended by way of lineswitch LS, local first selector S, intermediate selector S1, and connector C in the well known manner. Local calls of this kind involving similar switches are described in detail in the previously referred to Wicks application, Serial No. 395,882 and will not be described in detail here.

The subscriber at substation T in calling a subscriber at substation T3 in the second exchange completes the call in the usual manner by dialling the number of the wanted subscriber's telephone. Lineswitch LS operates the usual way to extend the calling line to a local first selector S which is then dialled up to the level assigned to trunks extending to the second exchange, which in this case will be assumed to be the sixth level. The selector seizes an idle trunk which may be the one terminating in repeater R, and the connection is then extended over the trunk line TL to repeater R1 and through that repeater to a selector S2. Incoming selector ITS is disconnected from the trunk and lineswitch LS1 operates to connect up an idle regenerating repeater, such as repeater G. The calling subscriber now dials the remaining digits of the wanted subscriber's number, these digits being recorded in the regenerating repeater which in turn retransmits corresponding impulses through repeaters R and R1 to operate selectors S2 and S3 and connector C1. In case the called line is idle connector C1 signals the wanted subscriber, and when that subscriber answers, returns a supervisory condition over the trunk whereby the individual timing switch IT operates to start the metering of the call under control of the various common timing switches. The regenerating repeater is released as soon as the idle line is connected with or, in the case of an incompleted call, is released after a predetermined time. In the event that the called line is busy in a local connection, repeater R1 will operate to cause the connector switch C1 to cut-in on the busy line and momentarily apply a busy tone both to the trunk and to the wanted line. After a short interval repeater R1 will then cause the connector to release the local connection and establish the trunk connection. In case the line is busy in a toll call a busy tone will be given to the calling subscriber but no further operations will take place.

Should the subscriber at substation T desire to call the toll operator, the procedure would be the same as in the previous call except that the first two digits would so position the distributor switch DS in repeater

R1, that the local switch train including selectors S2 and S3 would be released and the call extended over the trunk TA to the operator's position. The operator would then further extend the call by way of a link circuit, such as L, and would further control the metering by operating one of the metering keys. The particular key operated determines whether the calling subscriber's meter will be operated once for each unit of time or a plurality of times for each unit of time consumed by the call.

The subscriber in the second exchange, such as the subscriber at substation T2, on calling subscriber in the first exchange, will dial the two digit code assigned to the operator whereby the call will be extended over a trunk line, such as TR. The operator on determining the number of the wanted subscriber will establish a connection with an idle trunk, such as the trunk TA, by means of a link circuit L, and will then connect up the dialling cord DC to the selected trunk and dial the wanted subscriber's number. Selectors corresponding to incoming selector ITS and intermediate selector S1 and a connector, such as C, will be positioned to extend the call to the wanted subscriber's line. If the wanted line is idle the connection is completed in the usual way, however, if it is busy in a local connection the operator is given a distinctive tone and may then interrupt the local connection and complete the trunk connection. The timing switch IT and regenerating repeater G do not function in this type of connection.

Toll calls are completed in exactly the same manner as the previously described trunk connection from the second exchange to the first exchange.

In connection with the metering switches it may be pointed out that the switches shown are normally connected up to provide this service. In case the regular apparatus fails to function properly, the transfer circuits TT automatically disconnect the regular apparatus and connect up the auxiliary apparatus so that at no time will the exchange be without the necessary metering device.

Having briefly described the apparatus and the operations involved in setting up various connections a detailed description will now be entered on.

A call from substation T in the first exchange to substation T2 in the second exchange will first be described. When the subscriber in substation T lifts his receiver, the usual loop circuit is established and lineswitch LS operates in the well known manner to select an idle trunk, which, in this instance, will be assumed to be the trunk extending to selector S. Relay 101 will operate over a circuit from battery, lower winding of relay 102, left-hand coil of relay 101, contacts 137, contacts 5 of the lineswitch bank, through the lineswitch, line conductor 1, through the loop of the calling substation, conductor 2, through the lineswitch, contacts 8 of the lineswitch bank, contacts 145, right-hand coil of relay 101, upper winding of relay 102 to ground. Relay 102, which is differentially wound, does not operate at this time. Relay 101 on operating closes a circuit from ground, contacts 127, winding of relay 108, both windings of relay 107 in series to battery, and in parallel with relay 107, through contacts 119 and 179, winding of vertical magnet 112 to battery. Relay 108 operates, but due to its resistance, relay 107 and magnet 112, do not operate at present. Relay 101 also closes a circuit from battery through the lower winding of relay 102, winding of relay 103, contacts 125, 138, and 173, upper winding of relay 106 to ground. Relays 103 and 106 operate over this circuit but relay 102 does not operate due to the resistance of the upper winding of relay 106. Relay 108 upon operating connects ground to the release trunk at contacts 163 to hold the lineswitch in operated position and for other purposes which will become apparent as the description progresses. Relay 108 also prepares the impulsing circuit at contacts 165. Relay 106 upon operating connects dial tone to the upper talking conductor by way of off-normal contacts 123 and contacts 148, prepares the circuit of relay 110 at contacts 150, and closes a holding circuit for its lower winding by way of contacts 152 and 133. The calling subscriber on hearing the dial tone is advised that a free switch has been seized and that dialling may commence.

It may be assumed, for the purpose of this description, that the number of the wanted substation is 65432 and that the calling subscriber proceeds to dial this number in the instant connection. The calling loop is therefore interrupted six times by the calling device at the substation in response to the dialling of the first digit and relay 101 responds accordingly. Each time relay 101 restores, relay 108 is short-circuited at contacts 128 and relay 107 and magnet 112 operate due to the increased current flow. Relay 107 is slow-to-deenergize due to its series connection with relay 108 and consequently, remains operated throughout the series of impulses. Magnet 112 operates for each impulse and raises the wipers step-by-step to the sixth level. With each impulse a holding circuit is completed for relay 103 extending from the winding of that relay, contacts 126, resistance 114, off-normal contacts 124 closed on the first vertical step of the wipers, contacts 130, 139, and 158, to ground. Relay 102 is prevented from operating at this time by the resistance 114 in the above circuit. When relay 107 restores shortly after the last impulse of the series, a circuit is completed from ground at con-

tacts 163, off-normal contacts 124, contacts 130, 139, 157, 177, and 118 through the winding of rotary magnet 111, to battery. The rotary magnet operates and steps the wipers in on the first set of contacts on the sixth level. In case the trunk terminating in these contacts is busy, wiper 182 will encounter a ground with the result that magnet 111, which in the meantime has interrupted its own circuit at contacts 118 and deenergized, will again operate over the previously traced circuit and advance the wipers to the next set of contacts. Assume that the first idle trunk encountered is the trunk comprising conductors 43—45 terminating in repeater R (Fig. 3). The following circuit is completed when this trunk is reached: ground, contacts 164 and 150, upper winding of relay 110, wiper 182, conductor 44, contacts 238, conductor 368, winding of relay 301 to battery. Relays 110 and 301 operate over the above circuit. Relay 110 stops further rotation of the switch by opening contacts 177 and at contacts 176 closes a holding circuit for its lower winding in series with magnet 111. Magnet 111 does not operate at this time due to the high resistance of the winding of relay 110. The talking conductors are connected through at contacts 172 and 180, the upper winding of relay 105 is connected in parallel with the upper winding of relay 110 by the closure of contacts 175 but this relay has no functions to perform in the present call. The vertical magnet is disconnected at contacts 179 and the upper winding of relay 107 is short-circuited at contacts 178. The purpose of this last operation is to provide sufficient current flow to maintain relay 108 energized after the vertical magnet is disconnected.

Referring now to Fig. 3, relay 301 upon operating closes a circuit from ground, contacts 319 and 327, lower winding of magnet 381 of lineswitch LS1, contacts 382 to battery at the master switch MS. Magnet 381 operates and forces the plunger into the banks to close contacts 392—395 and also completes a holding circuit for its two windings in series by opening contacts 382 and closing contacts 383. The closure of contacts 392 marks the trunk busy and causes the master switch to align the remaining plungers opposite another trunk. It has been assumed, for convenience, that the lineswitch is standing opposite the trunk comprising conductors 396—399 terminating in the regenerating repeater G. A circuit may now be traced from battery, lower winding of relay 102, winding of relay 103, contacts 125, 138, and 172, wiper 181, conductor 43, conductor 367, contacts 315, conductor 386, contacts 395, conductor 399, through the winding of relay 401 to ground. Relay 103, which was previously held energized over a local circuit in the selector S, is now held operated over the above-traced circuit, and in turn maintains the holding circuit for relay 106. It may be mentioned at this point, that in local calls the circuit for relay 103 will extend over wiper 181 and through the impulsing relay of the local switch thence back over wiper 183, contacts, 180 and 144, winding of relay 104 to ground. A loop circuit has been dispensed with in the present instance for purposes which will be clear when the further operations of the switches is considered.

Referring again to Fig. 3, relay 301 in operating further connects ground to conductor 377 at contacts 316 for purposes which will be described later, disconnects ground from conductor 369 at contacts 318 and prepares a holding circuit for relay 302 at contacts 317, and connects the dialling leg of the associated trunk line, conductor 380, by way of contacts 322 and 329, conductor 385, contacts 394, conductor 398, contacts 438, upper winding of relay 409 to battery. Conductor 380 which is the dialling leg of the trunk line TL, extends to ground at the distant office as will be subsequently explained and relay 409 consequently operates and closes a circuit from ground, contacts 442, conductor 397, contacts 393, conductor 384, upper winding of relay 302 to battery. Relay 302 is a two-step relay and operates only its contacts 324 at this time. The lower or operating winding is now short-circuited by ground through contacts 317 and the relay consequently remains in its first position until ground is removed from conductor 384.

Referring now to Fig. 4, relay 401 operating, closes a circuit for relay 402 at contacts 418. Relay 402 operates, connects ground to test conductor 396 at contacts 420, closes a point in the automatic releasing circuit at contacts 421, prepares the impulsing circuit of contacts 422, and grounds the local holding conductor 461 at contacts 424. Relay 411 operates from ground on conductor 461 by way of contacts 451, and connects ground to holding conductor 464 at contacts 446.

The calling subscriber now dials the second digit of the called number, that is, the digit 5, and relay 101 responds as in the previous instance. The circuit of relay 401, previously traced, is intermittently opened at contacts 125, and relay 401 deenergizes and reenergizes in step with relay 101. The previously noted holding circuit for relay 103 is again closed at contacts 126 during the transmission of this series of impulses. Each time relay 401 retracts its armatures, a circuit is closed from ground, contacts 419 and 422, winding of relay 403, conductor 460, contacts 426′ and 436′, winding of stepping magnet 409′ of register switch RS1 to battery. Magnet 409′ operates in response to these impulses and steps wiper 415′ around to the fifth contact, that is, contact 478′, of its bank. Relay

403 operates in response to the first impulse, and due to its slow-releasing character, remains operated throughout the series of impulses. A circuit is thereby closed from ground at contacts 424, contacts 428, conductor 462, contacts 433′ and 424′, lower winding of relay 401′ to battery. Relay 401′, which is a two-step relay, operates in its first step over the above circuit and closes only its contacts 422′, thereby preparing its operating circuit. Shortly after the last impulse of the series, relay 403 restores and removes ground from conductor 462. Relay 401′ now operates in its second step from ground on conductor 461, contacts 428′ and 422′, and the two windings of the relay in series. The impulsing circuit, including conductor 460, is transferred by way of contacts 425′ and 435′ to magnet 410′ of register switch RS2. Conductor 462 is disconnected from relay 401′ at contacts 424′ and connected instead to relay 402′ by way of contacts 423′ and 431′. Off-normal contacts 418′, which close when wiper 415′ is moved from normal position, complete an auxiliary holding circuit for relay 401′ to keep that relay operated as long as the register switch RS1 is off-normal.

Relay 401′ upon operating in its second step also completes a circuit from ground through the winding of release magnet 412′ of register switch RS1, contacts 427′, conductor 463, wiper 416 of control switch CS in first position, winding of relay 413 to battery. Relay 413 operates over this circuit but the magnet does not. Relay 413 closes a circuit from ground, contacts 453, 455, and 441, winding of relay 406 to battery. Relay 406 operates, completes a temporary locking circuit for itself at contacts 436 and closes a circuit for relay 407 at contacts 435. Relay 407 operates and closes a circuit for relay 408 at contacts 440. Relay 407 also disconnects relay 409 from conductor 398 thus transmitting an impulse over the dial leg of the trunk. A temporary holding circuit is closed for relay 409 at each impulse, this circuit extending over contacts 439 and resistance 458 to ground at contacts 424. Relay 409, therefore, remains operated and maintains the ground on conductor 397 so that relay 302 is prevented from operating in its second step at this time. Relay 408 now operates and opens the circuit of relay 406 which deenergizes and in turn opens the circuit of relay 407. Relay 407 restores, reconnects battery to relay 409 to conductor 398 and opens the circuit of relay 408 which likewise restores. This cycle of operation is repeated for each impulse. The length of the impulses and the intervals between them can be very accurately regulated by varying the adjustment of the relays 406—408. Incidentally relay 401 may be adjusted to operate over a wide range so that it will respond properly to impulses which may be somewhat distorted by being repeated through several tandem exchanges, or by variation in the calling devices at the subscriber's substation. The impulsing relays, however, will retransmit the impulses over the trunk entirely free from distortion and at the proper rate of speed to give the best results with the equipment used. These relays further control the impulse ratio, that is the ratio between the open circuit and closed circuit periods of each impulse, and by proper adjustment will transmit the particular type of impulse for which the switching apparatus is adjusted.

Each time relay 406 operates, a circuit is closed from ground at contacts 436 or 453, contacts 437 to conductor 465. During the transmission of the first impulses, this ground extending through contacts 469′, 462′, 455′, and 448′, through the lower winding of relay 404′ to battery, causes relay 404′ to operate in its first step and prepare a circuit for both of its windings in series at contacts 446′. Relay 406 restores at the end of the impulse and disconnects ground from conductor 465 by opening contacts 437, thereby removing the short circuit from the upper winding of relay 404′ and that relay operates in its second step. The operating circuit including conductor 465 is thereby transferred to relay 405′ by way of contacts 447′. Relay 404′ remains operated over contacts 446′ and and 451′, and conductor 464 to ground at contacts 446. On the transmission of the second impulse, relay 405′ operates in the same manner as relay 404′ had previously operated, and the impulsing conductor is transferred to relay 406′ at contacts 454′. Relay 405′ opens the circuit of relay 404′ at contacts 451′ and that relay restores. Relay 406′ responds to the third impulse, relay 407′ responds to the fourth impulse, and relay 408′ responds to the fifth impulse, which, in this case, is assumed to correspond to the digit registered on switch RS1. A circuit is now closed from battery, winding of relay 412, contacts 450, conductor 466, contacts 477′, contact 478′ of the bank register switch RS1, wiper 415′, wiper 417 of control switch CS in first position, contacts 455 and 453, to ground. Relay 412 operates over this circuit and locks to conductor 464 at contacts 449, opens the circuit of relay 411 at contacts 451, disconnects ground from the previously-traced operating circuit at contacts 453, and shunts relay 413 with battery through resistance 467 at contacts 454. Relay 412 prevents the further operation of the impulse relays by opening contacts 453. The current flow through resistance 467, which is now connected in parallel with relay 413, is sufficient to cause the operation of release magnet 412′, which restores wiper 415′ to normal position. Off-normal contacts 418′ are now opened, and in the event that the second digit

of the called number has been registered and relay 402′ operated, the holding circuit of relay 401′ will be opened so that the relay will restore.

The second digit dialled by the calling subscriber is registered on switch RS2, relay 402′ operating in its second step at the end of a series of impulses in the same manner as described for the registration of the first digit. The impulsing lead 460 is then transferred to magnet 411′ of register switch RS3 by way of contacts 425′ and 434′ in case both relays 401′ and 402′ are operated and over contacts 426′ and 436′ after relay 401′ restores. The third digit is registered on switch RS3 and relay 403′ operates in its second step shortly after the last impulse of the series and transfers impulse conductor 460 back to magnet 409′ of register switch RS1. The above cycle of operation is repeated for subsequent digits, the fourth, fifth, and sixth (if there are that many) being registered respectively on register switches RS1, RS2, and RS3. The retransmission of impulses is very rapid and the first register switch is cleared before the calling subscriber can possibly dial the fourth digit.

Referring back to the retransmission of the first digit, relay 412 upon operating opened the circuit of relay 411. Relay 411 is slow-to-release and a short interval after its circuit is opened the relay restores, opens the circuit of relay 412, and closes a point in the circuit of stepping magnet 456 of control switch CS at contacts 447. Relay 412 is also slow-to-release and maintains its armatures operated a short interval after its circuit is opened. During this interval magnet 456 is operated from ground by way of contacts 452 and 457, and wipers 416 and 417 are advanced to second position.

The retransmission of the second digit is similar to that of the first digit, the starting circuit, however, extending through contacts 438′ and wiper 416 of control switch CS in second position. The stopping circuit for this digit includes wiper 416′ of register switch RS2, on which the second digit was registered, and wiper 417 of control switch CS in second position.

The manner in which subsequent digits are retransmitted will be obvious from the foregoing description. The first, fourth, and seventh contacts; second, fifth, and eighth contacts; and third, sixth, and ninth contacts of the banks of the control switch CS are multiplied so that the register switches RS1, RS2, and RS3, will function, respectively, for each fourth digit of a called number.

The release of relay 411, as previously described, removes ground from conductor 464 at contacts 446 and any of relays 404′—408′, which were previously locked up, are released and the apparatus is in condition to retransmit the second impulse.

The operation of the counting relays was described for the retransmission of a digit comprising five impulses. For digits comprising a greater number of impulses, such as ten impulses, for example, relays 404′—408′ will operate responsive to the transmission of the first five impulses in the same manner as previously described. Relay 408′ will remain locked up permanently, and relays 404′—407′ will release. Relay 404′ will lock permanently for the sixth impulse, relays 405′ and 406′ will lock temporarily for the seventh and eighth impulses, respectively, relay 407′ will lock permanently for the ninth impulse, and relay 405′ will lock permanently for the tenth impulse. Relay 406′ is available for an eleventh impulse if such is required. The operation of the counting relays in the above manner connects ground to successive contacts of the register switch banks, the wipers of which are positioned according to the digit to be retransmitted. The release relay 411, after each digit, restores the counting relays to normal in the usual way.

It may be noted here that an impulse of ground is transmitted over conductor 376 at intervals of, for example, every 4⅔ seconds. The first impulse on this conductor after the switch G is seized operates relay 410 which locks by way of contacts 445 and 429 to ground at contacts 424. Relay 410 connects relay 409 to the conductor 376 at contacts 444. However, in case the calling subscriber dials a digit before the elapse of an additional interval of 4⅔ seconds, relay 403 will open the holding circuit of relay 410 at contacts 429 and relay 410 will accordingly release. In the event that the subscriber fails to dial within the above interval, or in case an incomplete number has been dialled and relay 403 is not again operated, the ground on conductor 376 will energize the lower winding of relay 409 which opposes the upper winding of the relay, and relay 409 will restore and remove ground from conductor 398 at contacts 442. This operation will initiate the switch-over at the repeater as will be subsequently explained.

The connection of relay 409 to the dial leg conductor 380 of the trunk when an idle regenerating repeater is seized, and the interruption of this connection to retransmit impulses has been described.

Referring now to Fig. 7, parts 1 and 2, in which is shown the repeater terminating the distant end of the trunk line, battery on conductor 380 through retardation coil RT, trunk conductor 715, retardation coil RT1, conductor 716, contacts 762 and 727, upper winding of relay 702 to ground, causes relay 702 to operate. It may be mentioned here that the trunk line shown is composited according to the well known manner, but that a

simplexed line will obviously operate equally well. Relay 702 upon operating, closes a circuit from ground, contacts 733, winding of relay 703, windings of relay 704 to battery and in parallel with relay 704, through contacts 760 and 766, magnet 710 of the discriminating switch DS to battery. Relay 703 operates, but due to its resistance, relay 704 and the magnet do not operate. Relay 703 closes points in the impulsing circuit at contacts 735 and 741, connects ground to the local holding conductor 789 at contacts 737, prepares the local impulsing circuit at contacts 739, and prepares a holding circuit for itself at contacts 738. Ground on conductor 789 by way of contacts 722, conductor 787, off-normal contacts 907 of selector S2, (Fig. 9) through the lower winding of relay 901 to battery, energizes relay 901. Relay 901 removes the short circuit from its upper winding by opening contacts 915 and connects its two winding series at contacts 916 to be effective when off-normal contacts 907 operate on the first vertical step.

The second digit of the called number is retransmitted by the regenerating repeater G, as previously described, the circuit of relay 702 being opened five times in this case. Relay 702 accordingly responds, dropping back five times to short-circuit relay 703 by closing contacts 734, thereby operating relay 704 and magnet 710 of discriminating switch DS. Relay 704 is slow-acting due to its series connection with relay 703 and remains operated throughout the series of impulses. Magnet 710 responds in the usual way and advances wiper 713 to the fifth contact of the bank. Relay 702 further transmits five impulses to the impulse relay of selector S2 over a circuit extending from ground, contacts 732, 735, and 718, upper righthand winding of repeating coil RC1, contacts 717, conductor 786, rotary off-normal contacts 906 of selector S2, through the windings of relay 902 to battery. Relay 704 meanwhile has disconnected relay 705 from conductor 786 for purposes to be described hereinafter. Relay 704 also connects battery to the lower talking conductor of the trunk through resistance 712, contacts 744, 741, and 729, lower right-hand winding of repeating coil RC1, contacts 730, conductor 788. The battery on the lower talking conductor has no utility in the present instance. Relay 902 of selector S2 responds to the impulse energizing five times to close a circuit from ground, contacts 917, normally closed rotary off-normal contacts 909 and 910, contacts 920, lower winding of relay 903 to battery and in parallel therewith, contacts 921, winding of vertical magnet 905 to battery. Relay 903 energizes and opens the circuit of the rotary magnet at contacts 925. The vertical magnet also responds and raises the switch wipers opposite the called level in this case level five. Shortly after the last impulse of the series, relay 704 restores and reconnects relay 705 to the upper talking conductor of the trunk which is without effect, however, at this time. In the selector relay 903 restores shortly after the last impulse of the series, it being rendered slow-to-release by the short circuit of its upper winding closed at contacts 923. Relay 903 on restoring closes a circuit from ground, contacts 919 of relay 902 which restored after the last impulse, contacts 925, off-normal contacts 908 which close on the first vertical step of the wipers, winding of rotary magnet 904 to battery. The rotary magnet operates over this circuit and steps the wipers 927—929 in on the first set of contacts in the fifth level. With the first rotary step of the wipers, rotary off-normal contacts 906, 909, and 910 open. The selector now hunts for an idle trunk, that is, one marked by battery on the test conductor. Assume that the trunk comprising conductors 933—935 is the first idle trunk. When the wipers come to the contacts associated with this trunk, battery through the relay of switch S3 (corresponding to relay 901 of switch S2) over conductor 934, wiper 928, the two upper windings of relay 903 in series, contacts 912 to ground, will cause relay 903 to operate and open the rotary stepping circuit at contacts 925. The talking conductors will be connected through at contacts 922 and 926 and the high resistance middle winding of relay 903 will be short circuited at contacts 923 to mark the trunk busy to other selectors in the exchange.

Referring now to repeater R1, Fig. 7, when relay 704 deenergizes, shortly after the last impulse of the series, a circuit is closed from ground, contacts 737, 743, and 784, wiper 713 which is now standing on the fifth contact of its bank, through the multipled contacts and winding of relay 707 to battery. Relay 707 operates and locks to ground on the local holding conductor 789 at contacts 764, opens a point in the circuit of relay 701 at contacts 763, disconnects stepping magnet 710 from in series with relay 703 at contacts 766, and short circuits the high resistance lower winding of relay 704 at contacts 765. The purpose of short circuiting the lower winding of relay 704 is to increase the current flow in the circuit in order that relay 703 will not deenergize when magnet 710 is disconnected.

The third digit of the called number, that is, the second to be transmitted over the trunk line, or the digit 4, is repeated in the same way by relay 702 and operates the selector S3 to the fourth level. This selector then cuts in and rotates in search of an idle trunk. It will be assumed too that the trunk comprising conductors 936—938 extending to connector C1 is the one selected. The switching relay of selector S3, corresponding to the relay 903 of selector S2, and relay 1001 of the

connector now operate in series over conductor 937, lower winding of relay 1001, sequence switch wiper III in first position, to battery. Relay 1001 on operating prepares a holding circuit for its two windings in series at contacts 1023, which will be effective when the sequence switch moves out of the first position.

The sequence switch wipers referred to are indicated in the drawings by two contacts connected by a dotted line. Each set of contacts is designated with both a roman numeral and an arabic numeral. The former indicates the wiper and the latter the position in which this wiper is effective to connect the contacts.

The fourth digit of the called telephone number is now transmitted over the trunk line and relay 702 responds in the usual way transmitting the corresponding number of impulses over the upper talking conductor of the trunk as previously traced to selector S2. The conductor has now been extended by way of contacts 922 and corresponding contacts of the switching relay of selector S3 to conductor 936. The ground impulses over this conductor by way of contacts 1038, sequence switch wiper II in first position, two windings of relay 1006 in series, resistance 1017 to battery, causes relay 1006 to operate a number of times corresponding to the impulses transmitted, in this case three times, since the fourth digit of the called number is 3. With each energization of relay 1006 a circuit is closed from ground, contacts 1054, upper winding of relay 1007, sequence switch wiper IV in first position, winding of vertical magnet 1013 to battery. The vertical magnet responds and raises the wipers to the third level. Relay 1007 operates in response to the first impulse and, being slow-to-release, remains operated throughout the series of impulses. Shortly after the last impulse of the series, relay 1007 restores and closes a circuit from ground, contact 1086 and 1057, sequence switch wiper I in first position, off-normal contacts 1020 which closed on the first vertical step of the wipers, winding of relay 1009, resistance 1087 to battery. Relay 1009 operates and closes a circuit for sequence switch magnet 1012 at contacts 1065. Magnet 1012 operates and moves the wipers of the sequence switch to the second position and short circuits relay 1009 at contacts 1066. Relay 1009 therefore releases and opens the circuit of the magnet 1012 which likewise releases.

The final digit is now transmitted by the impulse sender and is repeated by relay 702 as in the previous case. Relay 1006 again responds, its circuit now being closed over sequence switch wiper II in second position and the previously-traced circuit including the upper talking conductor. Relay 1006 on operating now transmits impulses from ground, contacts 1054, upper winding of relay 1007, sequence switch wiper IV in second position, winding of rotary magnet 1014 to battery. The rotary magnet responds and steps the switch wipers around to the contacts of the called line which will be assumed to be the contacts associated with the line comprising conductor 1083—1085 extending to substation T2. When relay 1007 restores shortly after the last impulse of the series, a circuit is closed from ground, contacts 1086 and 1057, off-normal contacts 1018 closed on the first rotary step of the wipers, sequence switch wiper III in second position, two windings of relay 1003 in series, winding of magnet 1014, to battery. Relay 1003 operates in this circuit, but due to its resistance, magnet 1014 does not operate. Relay 1003 closes a circuit from ground, contacts 1055 and 1040, sequence switch wiper I in second position, winding of relay 1009, resistance 1087 to battery, and relay 1009 again operates to close the circuit of sequence switch magnet 1012. Magnet 1012 operates to advance the wipers to third position.

It will be recalled that after each series of impulses relay 705 of repeater R1 is connected to the upper talking conductor. When the sequence switch of the connector reaches third position, a circuit is completed from battery, winding of relay 705, contacts 752, 742, 731, 735, and 718, upper right-hand winding of repeating coil RC1, contacts 717, conductor 786, thence over the upper talking conductor and wipers of selectors S2 and S3, conductor 936, sequence switch wiper III in third position, upper winding of relay 1002 to ground. Both relays operate over the above circuit. Relay 1002 closing a holding circuit for itself and relay 1007 in series over contacts 1034 and 1035, sequence switch wiper V in third position, to ground at contacts 1021. Relay 705 on operating closes a temporary locking circuit for itself at contacts 746 and closes a circuit from ground, contacts 748, 731′, 737, and 783, winding of relay 706 to battery. Relay 706 operates, closes points in the talking circuit at contacts 751 and 753, opens the original energizing circuit of relay 705 at contacts 752, completes a locking circuit for itself at contacts 758, disconnects magnet 710 of discriminating switch DS at contacts 760, short circuits the high resistance lower winding of relay 704 for purposes previously discussed at contacts 765, and disconnects the dial leg of the trunk from relay 702 at contacts 762 and connects it instead to relay 709′ at contacts 761. The upper winding of relay 709′ has a very high resistance, for example, a resistance of twelve thousand ohms, while the lower winding has a much lower resistance, for example, six hundred ohms. Relay 709′ operates from battery on the dial leg and closes a holding circuit for the lower winding of relay 702 at con-

tacts 741′. The high resistance now connected in the circuit including the dialling leg of the trunk, causes certain operations at the first exchange which will be explained in later paragraphs.

In the meantime the sequence switch of the connector is advanced to fourth position by ground through interrupter 1088 and sequence switch wiper I in third position which completes an operating circuit for relay 1009. When the sequence switch moves out of third position, the previously-traced circuit of relay 705 and 1002 is opened and relay 705 restores. Relay 1002, however, remains locked up in series with relay 1007 which is also operated. Relay 705 on restoring completes a circuit which may be traced from battery, resistance 711′, contacts 740′, 750, 744, 741 and 729, lower right-hand winding of repeating coil RC1, contacts 730, conductor 788, thence over the lower talking conductors and wipers of selectors S2 and S3, conductor 938, upper winding of relay 1005, sequence switch wiper II in position 4, to ground at contacts 1086. Relay 1005 operates over the above circuit and closes an operating circuit for relay 1009 by way of contact 1051 and sequence switch wiper I in fourth position. Relay 1009 operates and the sequence switch is advanced to fifth position in the usual way.

When the sequence switch leaves fourth position, the circuit to relay 1003 will be opened and that relay will restore thereby completing the following circuit: ground, contacts 739′, upper winding of relay 707′ contacts 751, 747, 742, 731, 735, and 718, upper winding of repeating coil RC1, contacts 717, conductor 786, thence over the upper talking conductors and wipers of selectors S2 and S3, conductor 936, contacts 1038, upper winding of relay 1004, contacts 1031 and 1052, resistance 1017, to battery. Relay 707′ operates over this circuit and closes a circuit for relay 708′ at contact 733′. Relay 708′ is a two-step relay and operates only in its first step at this time, closing contacts 735′. Relay 1004 does not operate due to the resistance of relay 707′.

With the sequence switch in position V, the connector now proceeds to test the called line, which, incidentally may be idle, busy in a local connector, or busy in a toll connection. Assuming first that the line is idle, relay 1011 will operate over a circuit from battery through the cut-off relay of the lineswitch, test connector 1085, wiper 1081, both windings of relay 1011 in series, sequence switch wiper II in fifth position to ground at contacts 1021. Relay 1011 upon operating short circuits its high resistance lower winding at contacts 1075 and 1076, connects ground to relay 1008 at contacts 1077, and opens the busy-tone circuit at contacts 1079. The foregoing testing operation takes place during the interval between the time the sequence switch wipers arrive in fifth position, and the time required for relay 1003 to restore. A circuit is then closed for relay 1009 over sequence switch wiper I in fifth position at contacts 1041 and 1055. The side switch will accordingly advance to the sixth position. When the sequence switch leaves position 5, the shirt circuit will be removed from relay 1010 and that relay will energize in series with relay 1002 and 1007, the latter relays also remaining operated. Relay 1011 being operated, there will now be an energizing circuit for relay 1009 from ground at contacts 1077 and sequence switch wiper I in each of positions 6 to 9. The sequence switch will accordingly step to position 10. Relay 1010 also connects the talking conductors through to wipers 1080 and 1082 by closing contacts 1068 and 1073, and prepares the ringing circuit at contacts 1071.

Referring now to the stage of operation at which relay 705 released, a circuit is closed from ground at contacts 737, contacts 758, 783, 737′, 731′, 749, winding of relay 701′ to battery. Relay 701′ actuates its armature which causes its weighted spring to vibrate. Contacts 719′, are rapidly opened and closed while the spring is vibrating and after an interval the vibration will cease and the contacts will remain closed. Relay 704′ will then operate and close a circuit for relay 705′ by way of contacts 720 and 722′. Relay 705′ will operate and when its weighted spring comes to rest after a short interval, a circuit will be closed for relay 706′ at contacts 726′. The high resistance upper winding of relay 707′ is now shunted by ground through contacts 720, 729′, lower winding of relay 707′, and contacts 753. As previously mentioned, the lower winding of relay 707′ has a comparatively low resistance as compared with the upper winding of the relay so the current flow in the upper talking conductor is considerably increased at this time with the result that relay 1004 of the connector operates. Relay 706′ incidentally opens the circuit of relay 701′ at contacts 731′ and relay 701′ restores. Relay 701′ opens the circuit of relay 704′ which in turn opens the circuit of relay 705′ and that relay in turn opens the circuit of relay 706′. Relay 706′ upon restoring again closes the circuit of relay 701′ and the foregoing cycle of operation is repeated.

Referring now to the connector which, as previously stated, is connected to the called line with the sequence in tenth position and with relay 1010 operated. Relay 1005 will also be operated from battery at the repeater over the previously-traced circuit including the lower talking conductor of the trunk, upper winding of relay 1005, sequence switch wiper II in tenth position, contacts 1037 and 1086 to ground. Ringing current will now be applied to the called line by way of con-

ductor 1090, contacts 1071, lower winding of relay 1003, contacts 1045 and 1049, sequence switch wiper III in tenth position, contacts 1073 and wiper 1082 thence over the line and through the bells and condenser at the called substation, wiper 1080, contacts 1068, sequence switch wiper V in tenth position, winding of relay 1008 to ground at contacts 1077. The ringing circuit will be opened intermittently at contacts 1045 by the operation of relay 1004 when the high resistance winding of relay 707′ is shunted as previously described.

When the called subscriber answers, a direct current loop is closed for the previously-traced ringing circuit and relay 1003 operates and opens the circuit of relay 1005 at contacts 1037. Relay 1005 releases and completes the battery-feed circuit for the called line which may be traced from battery, resistance 1017, upper winding of relay 1006, contacts 1050, sequence switch wiper III in tenth position, contacts 1073, wiper 1082, line conductor 1084, through the loop at the called substation, line conductor 1083, wiper 1080, contacts 1068, sequence switch wiper V in tenth position, winding of relay 1008 to ground at contacts 1077. Relays 1006 and 1008 operate over this circuit. Relay 1006 opens the circuit over which relay 707′ has been held up in series with the upper winding of relay 1004, and relay 707′ consequently releases. Relay 707′ on releasing removes the short circuit from the upper winding of relay 708′ by opening contacts 733′ and relay 708′ operates in its second step. Relay 708′ on operating disconnects battery and ground from the two talking conductors respectively at contacts 740′ and 739′, and instead connects the upper winding of relay 707′ across the conductors at contacts 738′. Relay 707′, however, does not operate at this time since there is no battery connected to the upper trunk conductor with relay 1006 of the connector operated. With relay 707′ normal and relay 708′ operated, the high resistance upper winding of relay 709′ is shunted by ground through contacts 732′ and 734′ and resistance 710′. This condition initiates the metering operation at repeater R as will be explained hereinafter.

Referring to the point in the description of the operation at which relay 706 operated, it will be recalled that the dialling leg of the trunk line was extended to relay 709′ which was described as having a low resistance winding and a high resistance winding. These two windings are intially connected in series and reduce the current flow over the dialling conductor. It will be further recalled that relay 409 of the repeater G has been held operated over the dial leg of the trunk to ground at repeater R1. When the high resistance of relay 709′ is included in the circuit, the current flow decreases to a point at which relay 409 can no longer remain operated and the relay restores. Ground is disconnected from conductor 397 at contacts 442, thus removing the short circuit from the lower winding of two-step relay 302, and that relay operates in its second step. The dial leg of the trunk is now disconnected from relay 409 at contacts 329 and extended by way of contacts 328 through the winding of relay 303 and the lower winding of relay 307 to battery. The holding circuit of magnet 381 of lineswitch LS1 is opened at contacts 327 and a local holding circuit is completed at contacts 326. Magnet 381 releases and permits the plunger of the lineswitch to return to normal position, thereby opening contacts 392—395 and freeing the regenerating repeater G for other calls. Neither relay 303 nor relay 307 operate at this time due to the high resistance of relay 709′.

When the call is answered, the high resistance winding of relay 709′ is shunted by resistance 710′, as previously explained, and the current flow over the dialling leg of the trunk line is increased so that relay 303 operates. Relay 307 does not operate in series with resistance 710′ however.

Referring now to Figs. 5 and 6, the operation of the common timing switches MT, CT, and PT, will now be described. The pendulum timer PT is adapted to be started manually and to operate continuously. The weighted spring or pendulum 651 vibrates at a constant rate and alternately closes circuits for relays 609 and 610 at contacts 642 and 643, respectively, to ground by way of jumper 647. Relays 609 and 610 operating provide the energy which keeps the pendulum in motion and respectively close contacts 641 and 644.

Cam timer CT is operated only when a call is being metered and is controlled by the pendulum timer. The master timer MT likewise operates only during the metering of a call and is controlled in turn by the cam timer CT. The basic time interval at which calls are charged for may vary according to the requirements of the particular system involved. For convenience it is assumed that an interval of three minutes is in use. In this case, the pendulum 651 will be adjusted to vibrate at a rate of one hundred cycles in sixty-five seconds. At this rate of vibration an impulse will be transmitted over conductor 525 to the cam timer every sixty-five one-hundredths (65/100) of a second and the cam timer will step accordingly. Contacts 522 will, therefore, close every seven and one-fifth seconds and contacts 523 every four and two-thirds seconds. Contacts 522 control the master timer MT which will therefore take one step every seven and one-fifth seconds or twenty-five steps, a complete revolution, every three minutes. Contacts 523 connect ground to the kick-off conductor 376

every four and two-thirds seconds to prevent unnecessarily holding the regenerating repeater.

It will be recalled that when repeater R was seized to extend a call, relay 301 connected ground to conductor 377 at contacts 316. This ground operates relay 601 which closes the circuit from ground, contacts 613 and 621 to contacts of relay 609 of the pendulum timer PT. This ground also extends by way of contacts 619 and conductor 515 to wipers 513 and 514 of master timer MT. Wipers 513 and 514 are mounted 180 degrees apart so that they engage the bank contact on alternate revolutions of the switch. Alternate contacts of the banks are multiplied and connected via conductors 516 and 517 to relays 602 and 603, respectively, for purposes which will become apparent as the description proceeds. Since the pendulum 651 is vibrating continuously, relay 609 will operate momentarily every sixty-five hundredths of a second and close a circuit for relay 611 at contacts 641. Relay 611 operates and closes a circuit for the stepping magnet 524 of cam timer CT by way of contacts 648 and conductor 525. The cams 520 and 521 are therefore advanced step-by-step in a clockwise direction. Contacts 522 closing every seven and one-fifth seconds will complete a circuit for stepping magnet 510 of master timer MT by way of conductor 519 and contacts 621 and 613, and the wipers of the master timer will be advanced step-by-step making one complete cycle in three minutes. The switch MT is of the type in which the wipers are advanced on the back stroke of the magnet and consequently each time the magnet deenergizes and closes contacts 511, ground will be connected to the particular contact engaged by way of conductor 524 and contacts 623.

The foregoing operations take place continuously during the setting up of a call and until such time as the call is answered or until the connection is released. It may be noted here that the bank contacts of the master timer MT are multiple connected with the contacts of the banks of the various individual timing switches of which the timing switch IT is shown. Switch IT has three wipers engaging three separate banks. The upper and middle banks are multiplied with a slip of one, that is, the first contact of the middle bank is multipled with the second contact of the first bank. There is a slip of four between the contacts of the upper bank and the lower bank, that is, the first four contacts of the lower bank are connected respectively to the twenty-second twenty-fifth contacts of the upper bank. The purpose of this slip multiple will be discussed in greater detail in later paragraphs.

When the called subscriber answers, relay 303 operates as described and closes a circuit for relay 305 via contacts 330 and 345. Relay 304 locks up by way of contacts 334, 340, 326 and 319, closes a circuit for relay 310 at contacts 333, connects the upper winding of relay 306 to conductor 505 by way of contacts 332 and 343, and closes a circuit from ground, contacts 335 and 347, conductor 506, interrupter contacts 509, winding of stepping magnet 501 of timing switch IT, to battery. Magnet 501 operates advancing wipers 502—504 one step and opens its own circuit at interrupter contacts 509. It will be recalled that the master timer is operating at this time and successively grounds the various bank contacts over which wiper 512 rotates. Magnet 501 rapidly advances wipers 502—504 until wiper 502 encounters the contact on which wiper 512 of the master timer is resting at that particular instance, at which time a circuit is closed from ground, contacts 623, conductor 524, contacts 511, wiper 512, contact of the bank, which for convenience may be assumed to be the first contact of the bank engaged by wiper 502, that wiper, conductor 505, contacts 343 and 332, upper winding of relay 306, to battery. Relay 306 operates, opens the stepping circuit for magnet 501 at contacts 347, and connects its lower winding in series with the magnet at contacts 346. Relay 306 remains operated over this circuit but due to the resistance of the relay, magnet 501 does not operate. The wipers of the timing switch IT consequently come to rest on the contacts engaged by the wiper of master timer MT at this particular instant and to which the master switch wipers will be returned after the lapse of three minutes. Relay 306 disconnects itself from conductor 505 at contacts 343 and connects the conductor to relay 305 by way of contacts 344 and 338. Relay 305 which is a two-step relay now operates in its first step to close contacts 341. Relay 306 also prepares the metering circuit by closing contacts 348, and opens a point in the circuit of relay 304 at contacts 345. Relay 304 remains locked up over contacts 340.

After an interval of 7⅕ seconds the wipers of the master timer MT will be stepped to the next set of contacts, removing ground from conductor 505 and connecting it instead of conductor 507. When ground is removed from conductor 505 the short circuit will be removed from the lower winding of relay 305 and that relay will operate in its second step. Conductor 505 is thereby transferred to relay 308 by way of contacts 339, and the locking circuit of relay 304 is opened at contacts 340. Relay 304 now restores, opens the circuit of relay 310 at contacts 333, and completes the metering circuit by closing contacts 337 and opening contacts 336. Relay 310 is slow-to-release and during the interval which its armatures are held up after relay 304 restores, a circuit may be traced from battery, resistance 314, contacts 359, 363, 348, and

337, lower left-hand winding of repeating coil RC, conductor 374, conductor 45, wiper 183 of selector S, contacts 180 and 144, winding of relay 104, upper winding of relay 102, to ground. Incidentally the loop circuit over which relays 103 and 104 has been operated in series is opened at contacts 336 and 364 and consequently relay 103 deenergizes. Relay 104, however, remains operated over the above traced circuit, and the meter associated with the calling line is operated over a circuit extending from battery, resistance 184, contacts 167, 132, 135 and 185, contacts 6 of the lineswitch banks, winding of the meter 4, to ground. The meter registers one call unit at this time. It may be mentioned that relay 102 is prevented from operating in series with relay 104 by the resistance 314 in the circuit. A short time after its circuit is opened, relay 310 restores, disconnects battery from the previously described metering circuit at contacts 353, and again closes a loop circuit for operating relays 103 and 104 in series at contacts 364.

When the master timer MT moves to second position a ground is connected to conductor 507 but this has no utility in the present connection, since relay 307 of repeater R is not operated. The master timer continues to step and on the twenty-second step or approximately twenty-one seconds before the first three minute period is up, ground will be connected over wiper 504, conductor 508, contacts 342, upper winding of relay 309 to battery. Relay 309 will operate and connect a tone to the upper talking conductor by way of contacts 361 and 356. Relay 309 will also close a circuit for relay 310 at contacts 357 and relay 310 will operate, although somewhat slowly in this instance because of the shunt through resistance 313. Relay 310 on operating disconnects the tone from the line at contacts 361 and completes a locking circuit for the lower winding of relay 309 by way of contacts 362 and 358. Relay 310 incidentally opens the bridge across the incoming talking conductors at contacts 364, but this is without effect at this time since relay 309 has closed another point in the bridge at contacts 360. When the wipers of the master timer leave the twenty-second position the original circuit of relay 309 and the circuit of relay 310 will be opened and these relays will release. Relay 310, however, will maintain relay 309 operated until the bridge across the incoming talking conductors has been reestablished at contacts 364 in order to prevent a false operation of the meter.

The master timer continues to step and when the first contact is again reached after the lapse of three minutes from the first meter registration, ground will be connected over wiper 502, conductor 505, contacts 344, 339 and 351, lower winding of relay 308, to battery. Relay 308 is a two-step relay and when its lower winding is energized operates only its contacts 354 and 355. A circuit is now closed for relay 304 extending from ground, contacts 319, 326, 354 and 353, winding of relay 304 and the relay operates. Relay 304 closes a circuit for relay 310 at contacts 333 and again prepares the metering circuit by closing contacts 336, and opening contacts 337. The master timer leaves the first position, after the usual interval, and ground is removed from conductor 505. The short circuit is thereby removed from the upper winding of relay 308 and the relay operates in its second step, opens the circuit of relay 304 at contacts 353, and transfers conductor 505 to relay 311. Relay 304 now restores and opens the circuit of relay 310 which restores after an interval. A second metering impulse is now transmitted over the lower talking conductor in the same manner as the previously described first metering impulse.

The master timer continues to step and when the twenty-second contact is reached for the second time or approximately twenty-one seconds before the end of the second three minute period, ground is again connected to conductor 508 and relays 308 and 310 again operate to transmit a warning tone to the calling subscriber. When the master switch wipers reach the first bank contacts for the third time, that is, at the end of the second three minute period, a circuit is closed from ground over wiper 502, conductor 505, contacts 344, 339 and 352, winding of relay 311, to battery. Relay 311 operates, completes a locking circuit for itself at contacts 366 and connects direct ground to the upper talking conductor at contacts 365. Relay 104 of selector S is consequently short-circuited and released, opening the metering circuit at contacts 135 to prevent a false registration at this time. Relay 102 is unbalanced, since its upper winding is short-circuited and operates over its lower winding alone. A circuit is now closed from ground, contacts 131, off-normal contacts 122, which closed on the first vertical step to the wipers, winding of release magnet 113, to battery. Magnet 113 operates to restore the wipers to normal in the usual way. The circuit of the release magnet is maintained at contacts 142, by relay 105 which operates on the closure of contacts 129, and locks to ground at contacts 163 by way of contacts 141.

After being disconnected in the above manner the called subscriber will restore his receiver and relays 101 and 108 will deenergize in the usual manner followed by the deenergization of relays 105, 109 and 110. The removal of ground from conductor 44 will cause relay 301 of repeater R to restore, remove ground from the meter starting conductor 377 at contacts 315, open the local holding circuit at contacts 319, and transfer the dialling leg of the trunk from relays 303

and 307 to its normal connection to ground through relay 203.

The relays of repeater RR will restore to normal following the release of relay 301. In repeater R1 relay 709′ will restore when battery is disconnected from the dialling leg of the trunk and the holding circuit of relay 702 will be opened at contacts 741′. Relay 702 will restore followed by relays 703, 706, 707 and 708′ and the repeater will again be in normal condition. The removal of ground from conductor 787 will permit relay 901 of selector S2 to release and remove ground from conductor 934 to permit the release of selector S3, relay 903 of selector S2 will deenergize and close a circuit for the rotary magnet at contacts 925. Magnet 904 will operate, advance the wipers one step and close a circuit for the lower winding of relay 902, which will operate and interrupt the circuit of the rotary magnet at contacts 919. This stepping operation will be repeated until the wipers reach the eleventh position at which time they will be returned by gravity to the normal vertical position and by means of a spring will be rotated to the normal position. The removal of ground from conductor 937 will permit relay 1001 to release, thereby removing ground from the holding circuit of relays 1002, 1007 and 1010. Relay 1007 on restoring completes a circuit for relay 1009 by way of contacts 1061 and sequence switch wiper I in tenth position and the sequence switch moves to position eleven. In this position a circuit for relay 1009 is closed through sequence switch wiper I in eleventh position to ground at contacts 1077 and the sequence switch moves to twelfth position. Ground through interrupter 1088 and sequence switch yiper I in twelfth position, energizes relay 1009, to move the sequence switch to thirteenth position. Relays 1008 and 1011 restore in the meantime and a circuit is closed for relay 1009 through sequence switch wiper I in thirteenth position, to ground by way of contacts 1063, 1024 and 1055. The sequence switch moves to fourteenth position where a similar circuit is closed for relay 1009 over sequence switch wiper II in fourteenth position, and again over sequence switch wiper II in fifteenth position. The sequence switch is thus rapidly advanced from tenth to sixteenth position, responsive to the disconnection of the calling party. With the sequence switch in this position a circuit is closed from battery, resistance 1017, upper winding of relay 1006, contacts 1067, sequence switch wiper V is sixteenth position, off-normal contacts 1027, interrupter contacts 1028, contacts 1070 and 1078, to ground. Relay 1006 operates and closes a circuit from ground at contacts 1054, sequence switch wiper II in sixteenth position, winding of rotary magnet 1014, to battery. The rotary magnet energizes, steps the wipers to the next set of contacts and opens the circuit of relay 1006 at contacts 1028. Relay 1006 deenergizes, opens the circuit of magnet 1014 which also deenergizes and re-establishes the circuit of relay 1006 which reenergizes and re-establishes the circuit of magnet 1014. This stepping operation is repeated until the wipers are rotated past the last set of contacts, at which time they drop vertically by gravity and are then rotated back to normal position under spring pressure. When the wipers reach normal position off-normal contacts 1019 close and complete a circuit for relay 1009 by way of sequence switch wiper I in sixteenth position, and the sequence switch is stepped out of the sixteenth position to the first position and the connector is then ready to handle the next call.

In the foregoing connection it was assumed that the called line was idle. When a line busy in a toll connection is connected with, test wiper 1081 will encounter direct ground on the associated test contact and relay 1011 will not operate. The sequence switch, however, will move from position five to position six, as previously described, and relay 1010 will now be short circuited by ground on the test wiper through sequence switch wiper V in sixth position. Relays 1002 and 1007 will remain operated as before. A toll busy tone will now be connected over conductor 1091, contacts 1079, sequence switch wiper IV in sixth position, lower windings of relay 1004 and 1005 to ground. The upper windings of these relays are connected across the incoming talking conductors of the trunk and the tone in the lower windings will be induced in the upper windings and transmitted over the trunk line to the calling subscriber who is thus advised that the called subscriber cannot be reached at this time. The calling subscriber is expected to hang up and release the connection in the usual way.

A line busy in a local connection is marked by ground through a resistance. When such a line is connected with, relay 1011 does not operate but relay 1010 does and the sequence switch is moved out of sixth position by ground through contacts 1078 and 1069, and sequence switch wiper I in sixth position. In this position the local busy tone is connected to the lower winding of relays 1004 and 1005 by way of sequence switch wiper III in seventh position. Since relay 1010 is operated, a connection is completed to the called subscriber and the tone is audible to both the calling subscriber and the two subscribers engaged in the local connection. A circuit is completed for relay 1005 as described in the previous connection except that it now includes the sequence switch wiper V in seventh position. Relay 1005 operates over the above circuit and prepares a circuit for moving the sequence switch to eighth position. In repeater R1 relay 706′ will ener-

gize after an interval and short circuit the high resistance winding of relay 707′ and relay 1004 of the connector will operate in the usual way. Relay 1004 on operating will short-circuit relay 1010 by connecting ground through contacts 1048 and 1044, sequence switch wiper IV in seventh position, contacts 1034, to the upper terminal of relay 1010. Relay 1010 will release and close a circuit for moving the sequence switch from seventh position, the circuit including contacts 1078, 1070 and 1046, and sequence switch wiper I in seventh position. When the sequence switch reaches the eighth position the short circuit is removed from relay 1010 and that relay again operates. A sequence switch stepping circuit is now completed from ground, contacts 1078 and 1069, over sequence switch wiper I in eighth position and the wipers are advanced to the ninth position. In ninth position ground is connected to both sides of the line by way of sequence switch wipers III and IV. A differential relay in the first selector engaged in the local call, corresponding to the relay 102 of selector S, is unbalanced by ground on the line conductors, and the local connection is released in the well known manner. Relay 1011 of the connector then operates in series with the cut-off relay of the lineswitch to ground through sequence switch wiper V in ninth position.

Since the calling subscriber will not likely have hung up, cut-off relay 1003 will be operated and the battery feed relays 1006 and 1008 will operate over the called subscriber's loop exactly as described in the previous connection. Further operations such as metering and the release of the connection are the same as those described for a connection to an idle line.

Subscibers in the first exchange to call subscribers in other exchanges in the system to which direct dialling service is not provided or to extend calls to subscribers in distant exchanges will first call the toil operator. On dialling the code assigned to the operator, which may be for example the number 696, the call will be extended to the operator independent of any trunk selecting switches in the second exchange. As an example, a call from the substation T to the operator's position, Fig. 8, will be described. The subscriber at substation T lifts the receiver and lineswitch LS functions as in the previous connection to select an idle first selector which may be the selector S. The subscriber then dials the first digit and selector S operates in the manner previously described to select an idle trunk, which for convenience may be assumed to be the trunk comprising conductors 43—45 terminating in repeater R. Lineswitch LS1 operates to select an idle regenerating repeater, such as the repeater G and the control conductor is extended to that repeater. The subscriber then dials the last two digits of the operator's code which are registered in the repeater and retransmitted over the trunk line in exactly the same way that impulses were repeated in the call to a subscriber in the second exchange. Incoming repeater R1 functions in the usual way responsive to the extension of the call, and relay 702 responds to the impulses as in the previous instance. The first series of impulses transmitted over the trunk line operate selector S in the usual way and also the stepping magnet 710 of discriminating switch DS. In this connection, however, the wipers are stepped to the ninth contacts of the bank, and when relay 704 restores, shortly after the last impulse of the series, a circuit is closed from ground, contacts 737, 743 and 784, wiper 713 in ninth position, contacts 781, lower winding of relay 708 to battery, and in parallel with relay 708, through contacts 780, lower winding of relay 709, to battery. Relay 708 operates, closes a point in the cut-off circuit at contacts 768, completes a locking circuit for itself at contacts 769, opens the previously traced operating circuit of relays 708 and 709 at contacts 780 and 781, and at contacts 782 connects relay 706 to the sixth contact of the bank of the switch DS. Relay 709 on operating closes a circuit from ground through its low resistance upper winding, contacts 785, off-normal contacts 793, closed when wiper 713 is in an off-normal position, through the winding of release magnet 711, to battery. Both relay 709 and magnet 711 are operated over this circuit, relay 709 maintaining the circuit of wiper 713 open at contacts 784, and magnet 711 restores this wiper to normal position. The second series of impulses operate selector S3 and stepping magnet 710 in the usual way. Since the digit 6 is dialled wiper 713 will come to rest on the sixth contact in its bank, and when relay 704 restores shortly after the last impulse of the series, a circuit will be closed from ground, contacts 737, 743 and 784, wiper 713 in sixth position, contacts 782, winding of relay 706, to battery. Relay 706 operates, locks at contacts 758, and switches the repeater over to waiting condition as in the previous connection. A circuit is now closed from ground, contacts 768, 763 and 755, winding of cut-off relay 701, to battery. Relay 701 on operating opens the trunk extending to selector S2 at contacts 717, 722 and 730, and the selectors restore to normal in the usual way. A circuit is closed from ground, contacts 721 and 727′, conductor 808, lamp L at the operator's position, to battery. Lamp L lights to inform the operator that an incoming call is awaiting attention. Lamp L1 was previously lighted in the usual way by the grounding of conductor 804. The dialling leg of the trunk now extends over contacts 761, through the two windings of relay 709′ in series to ground. Relay 709′ is op-

erated and closes a holding circuit for relay 702 at contacts 741′. As in the previously described connection, the switching through of the dialling leg to relay 709′ brings about the disconnection of the regenerating repeater at the first exchange since relay 409 cannot remain energized in series with the two windings of relay 709′. The deenergization of relay 409 removes ground from conductor 397 and relay 302 is enabled to operate in its second step. The dialling leg of the trunk is thereby transferred via contacts 322 and 328, winding of relay 303, lower winding of relay 307, to battery. Neither relay operates at this time due to the high resistance of the upper winding of relay 709′.

The operator inserts the answering plug P of link L into jack J and may now converse with the calling subscriber, being connected with the trunk over a circuit extending from battery, resistance 713′, contacts 721′ and 719, upper right-hand winding of repeating coil RC1, conductor 802, ring of jack J, ring of plug P, through the operator's telephone circuit associated with the link L, tip of plug P, tip of jack J, conductor 801, lower right-hand winding of repeating coil RC1, contacts 728 and 724′, resistance 712′ to ground. Repeating coil RC1′ provides the inductive connection between the trunk line and the operator's circuit.

The operator will then extend the call to the wanted exchange by inserting the plug P1 into the jack of a trunk line extending to the wanted exchange, for example, the jack J3. If the call is for a subscriber in the same system in which the usual charge is made, the operator will actuate key K2, thereby shunting the high resistance upper winding of relay 709′ with resistance 710′. In repeater R relay 303 will operate, as in the previously described call to a subscriber in the second exchange, and the metering apparatus will function to transmit one metering impulse to the calling line at intervals of three minutes, in exactly the same manner as previously described. In case the call was to an exchange for which a higher charge is made, the operator will actuate key K3, instead of key K2, and the upper-high resistance winding of relay 709′ will be short-circuited by direct ground through contacts 814. In the repeater R. both relay 303 and 307 will operate, the latter relay locking over its upper winding by way of contacts 350. Now instead of receiving one impulse every three minutes as the master time rotates over the banks, the metering relay of the repeater will receive two impulses since both wiper 502 and 503 of the individual timer IT are connected up. It will be recalled that the contacts engaged by the wipers 502 and 503 are connected to the multiple with a slip of one, so that the master timer will connect ground to these wipers successively. Ground on 503 via conductor 507 and contacts 349 operates relay 304. This relay closes a circuit for relay 310 which operates. When ground is removed from wiper 503 as the master timer moves to third position, relays 304 and 310 deenergize and transmit the second metering impulse to the calling line. Near the end of the last three minutes of the call a warning tone will be sent out in the usual manner and at the end of this period the connection will be automatically released in case the subscribers have not yet hung up.

When the call is terminated either by the subscribers hanging up or by being automatically disconnected, the battery will be disconnected from the dial leg of the trunk and relay 709′ will restore and open the circuit of relay 702. Relay 702 will restore and open the circuit of relay 703 which will likewise restore and short circuit the high resistance winding of relay 702′ by connecting ground to the low resistance lower winding via way of contacts 740 and 723′. The usual supervisory relay of the cord circuit will now operate from the increased current flow over the sleeve conductor to give the operator disconnect supervision. The operator will then withdraw the plug P from jack J and the apparatus will restore to normal in the usual manner.

Calls from subscribers in the second exchange, as well as toll calls to subscribers in the first exchange are completed by an operator. By way of example, a call from substation T2 to substation T1 will be described. The subscriber at substation T2 on lifting the receiver and dialling the operator's code number will be connected via the lineswitch LS2 and selectors, such as selectors S5 and S4, to a trunk extending to the operator's position, which may be the trunk comprising conductors 840—842 terminating in trunk relay group TR. Relay 826 operates from ground on test conductor 841 when the call is extended, removes the short-circuit from its upper winding at contacts 839 and closes a circuit for lamp L2 at contacts 838. Lamp L2 lights to inform the operator that an incoming call is awaiting attention.

The operator answers the call by inserting the answering plug of a cord into the jack of the calling trunk, for instance the plug P1 of the cord L into jack J2. A circuit is closed for relay 825 at contacts 821 and relay 825 operates, shunts the upper winding of relay 824 and resistance 827 at contacts 832, opens the circuit of lamp L2 at contacts 833, and prepares a locking circuit for relay 824 at contacts 836. The operator then connects her telephone circuit to the cord in any known manner and converses with the calling subscriber, talking current being supplied by way of resistance 829, and resistance 828 and impedance 823. The busy lamp L3 will light

to mark the trunk busy at the various positions.

Since the call is for a subscriber in the first exchange, the operator will insert the calling plug of the cord into the jack of an idle trunk extending to the first exchange, for example, the jack J of trunk TA which will be assumed to be idle at this time. When the plug is inserted into the jack sleeve relay 702′ will operate from battery on the sleeve of the plug. The high resistance upper winding of realy 702′ is shunted by ground through the low resistance winding of the relay, and the supervisory lamp associated with the cord will light. Relay 702′ prepares the circuit of relay 703′ at contacts 716′ and 718′. The insertion of the plug into the jack also closes contacts 811 to complete parallel circuits over conductor 807 for relays 701 and 706′ which operate. Relay 701 disconnects selector S2 from trunk by opening contacts 717, 722 and 730, completes a circuit for busy lamp L1 at contacts 725, disconnects the dialling leg of the trunk from relay 702 at contacts 727 and extends it over contacts 726 and conductor 803 to the operator's position. A circuit may now be traced from battery, upper winding of relay 703′, resistance 742′, contacts 716′, conductor 806, contacts 812 of the dialling jack J1, conductor 803, contacts 726 and 761, conductor 716, retardation coil RC1, conductor 715, retardation coil RT, conductor 380, contacts 323, conductor 372, contacts 250, upper winding of relay 203, to ground. A circuit is also closed for the lower winding of relay 703′ by way of resistance 715′ and contacts 718′ and 730′. The two windings of the relay oppose each other and when both are energized the relay remains in normal position, as is the case at this time. Relay 203 of the incoming selector operates, closes a circuit at contacts 241 for relay 202 and vertical magnet 213 in series. Relay 201 is connected in parallel with the magnet, but neither that relay nor the magnet operate at this time due to the resistance of relay 202. Relay 202 also closes a circuit for the lower winding of the relay 205 over contacts 243, 267 and 256, conductor 373, contacts 321, lower-left-hand winding of repeating coil RC, conductor 374, contacts 297, conductor 375, to ground at contacts 320. Relay 202 disconnects the test conductor 44 from cut-off relay 301 by opening contacts 238, thereby marking the trunk busy to the selectors in the first exchange. Relay 205 on operating opens the circuit of relay 204 at contacts 258. Relay 209 operates from ground on the local holding conductor by way of contacts 251 and 283, and locks via contacts 270.

The operator will now insert the plug P2 of a dialling cord DC into jack J1 and will operate the dialling key K, thereby transferring the previously traced control circuit over which relay 203 was operated from battery through relay 703′, to battery, through impulsing contacts 815 of the calling device CD. The operator will then dial the first digit of the wanted subscriber's number. The circuit of relay 203 will be interrupted at impulse contacts 815 and the relay will respond in accordance with the particular digit dialled. Each time relay 203 drops back relay 202 is short-circuited at contacts 242, and relay 201 and magnet 213 energize. Relay 201 is slow-to-release due to a series connection with relay 202 and remains operated throughout the series of impulses. Magnet 213 operates in response to each impulse and raises the wipers step-by-step to the called level. During the transmission of impulses a holding circuit is closed for relay 205 by way of contacts 244, resistance 217, contacts 251 and 239, to ground. Relay 201 releases shortly after the last impulse of the series and closes a circuit from ground at contacts 239, off-normal contacts 225 which close on the first vertical step of the wipers, contacts 231, 237, 293 and 230, winding of rotary magnet 214, to battery. The rotary magnet operates, steps the wipers in on the first set of contacts of the called level and interrupts its own circuit at contacts 230. The magnet will continue to operate in a buzzer-like manner, advancing the wipers step-by-step until an idle trunk is found. By way of example it will be assumed that the idle trunk selected is the trunk comprising conductors 32—35 terminating in intermediate selector S1. Relay 212 operates in series with the release trunk relay of selector S1 over conductor 33 and wiper 203′, short-circuits its upper winding at contacts 291 to mark the trunk busy to other selectors in the exchange, opens the rotary stepping circuit at contacts 293, and locks over its lower winding and magnet 214 in series by way of contacts 292. Relay 212 disconnects the vertical magnet at contacts 295 and short-circuits the high resistance lower winding of relay 201 at contacts 294. The talking conductors of the switch are connected through to wipers 201′ and 204′ by the closure of contacts 290 and 296 and the original operating circuit of relay 205 is opened at contacts 297. Relay 205 is now held operated in series with the impulse relay of selector S1, the circuit extending now over contacts 296, wiper 204′, conductor 35, through the impulse relay of selector S1, and back over conductor 32, wiper 201′, contacts 290, and 273, conductor 367, upper-right-hand winding of repeating coil RC, conductor 370, contacts 247, conductor 369, to ground at contacts 318. The impulsing relay of the selector operates over the above circuit and prepares the selector for operation.

The operator now dials the second digit of the wanted subscriber's number and relay 203 responds as before. The above traced circuit for the impulse relay of selector S1 is opened for each impulse at contacts 243 and that relay responds to operate the selector to the called level in the usual way. The previously traced holding circuit for relay 205 is again closed during impulsing. Relay 201 again operates during the series of impulses and short-circuits the upper-left-hand winding of repeating coil RC at contacts 232 to provide a better impulsing circuit. Selector S1 operates in the well known manner to select an idle trunk, for example, the trunk comprising conductors 15—18, terminating in connector C. The control loop is now extended to the impulse relay of the connector and that relay and relay 205 are now energized in series.

It may be noted at this point that the connector is provided with a polarized relay connected in series with the impulse relay. When a connection is extended to the connector by a local selector such as the selector S, current through the impulse relay and polarized relay is in such direction that the polarized relay does not operate. In the present connection, however, current flow in the impulsing circuit is in such a direction that the polarized relay of the connector will operate and prepare the connector for toll operation.

The operator now dials the last two digits of the wanted subscriber's number. These digits are repeated by relay 203 as in the previous instance, and wipers 19—21 of the connector are stepped to the contacts to the called line, that is, the line comprising conductors 1′—3′ extending to substation T1. If the called line is idle, the connector cuts through in the usual way and opens the control circuit over which relay 205 of selector ITS has been held operated. Relay 205 then releases and closes a circuit for relay 204 over contacts 253, 258 and 239. Relay 204 operates, locks to the common holding conductor at contacts 252, opens the circuit of relay 209 at contacts 251, prepares the ring control circuit at contacts 246, removes the short circuit from the upper winding of relay 205 by opening contacts 247, and switches the incoming control circuit from relay 203 to relays 207 and 206 in series at contacts 250 and 249. Relay 206 operates over the control circuit and completes a holding circuit for relay 203 by way of contacts 251 and 254. The current flow in this circuit is not sufficient, however, to operate relay 207 at this time.

The ring cut-off relay of the connector is locked up in the usual manner so that the called subscriber is not signalled at this time. When the operator is ready to complete the connection, key K1 will be actuated, thereby connecting high voltage battery to the control circuit at contacts 817. Relay 207 of selector ITS will operate due to the increased current flow, and connect ground to the ring control wiper 202′ by way of contacts 262, 276 and 246. This ground extends over conductor 34, through the selector S1 to connector C, and shunts the ring cut-off relay of the connector so that that relay will restore and apply ringing current to the called line.

When the called subscriber answers, the ring cut-off relay of the connector will again operate and complete the talking connection. Relay 205 now feeds talking current to the called subscriber and operates over the called subscriber's loop the circuit extending from battery, lower winding of relay 205, contacts 243, 280 and 255, conductor 373, contacts 321, lower-left-hand handing of repeating coil RC, conductor 374, contacts 296, wiper 204′, conductor 35, upper talking conductor, and wipers of selector S1 and connector C, through the called subscriber's loop, back over the lower talking conductor and wipers of the connector and selector, conductor 32, wiper 201′, contacts 290 and 273, conductor 367, upper-left-hand winding of repeating coil RC, conductor 370, contacts 248, 278 and 263, upper winding of relay 205, conductor 369, to ground at contacts 318. Relay 205 operates, disconnects the ground from the incoming control circuit at contacts 260 and substitutes battery through resistance 218 by closing contacts 259. This battery holds relay 206 in operated position.

The operator will now withdraw plug P2 of the dialling cord from the jack and the control circuit will again be extended to the upper winding of relay 703′. This relay which will have operated over its lower winding during the connection of the dialling cord to the trunk, will now restore to normal at its upper winding will be energized over the control circuit and will oppose the lower winding which is energized in a local circuit. When battery is connected to the control circuit by the operation of relay 205 the upper winding of relay 703′ will be shunted and the relay will operate to close the circuit of relay 704′ at contacts 720′. Relay 704′ operates and opens the shunt around the high resistance upper winding of relay 702′ at contacts 723′. The current flow over the sleeve of the cord is thereby reduced to give the operator answering supervision by extinguishing the supervisory lamp.

When the called subscriber hangs up, relay 205 will release and restore the control circuit to normal condition whereon relay 703′ will again restore and open the circuit of relay 704′. Relay 704′ will release and again shunt the high resistance upper winding of relay 702′ to give the operator disconnect supervision. When the calling sub-

scriber hangs up, relay 826 will release and connect ground to the sleeve of the jack at contacts 827 to give disconnect supervision.

If the call is to be metered the operator will actuate the key K4 to close a circuit for relay 824. Relay 824 on operating completes a locking circuit for its lower winding by way of contacts 830 and 836, and short-circuits resistance 828 at contacts 831. This condition causes certain operations in the first selector which are well known and do not form a part of the invention and, therefore, will not be described in further detail.

On receiving the disconnect signal from both subscribers, the operator will withdraw the plugs of the cord from the jacks and relay 702′ will release. The control circuit over which selectors ITS and S1 and connector C were held operated is now opened at contacts 716′ and those switches release the usual way.

When a call such as has just been described is extended to a line which is busy in a local connection the sequence of operation is somewhat different from the preceding call. The busy line may be engaged in either an outgoing or in incoming call, that is, may be the line from which a local call originates or the line to which some other local subscriber has extended a connection. In either case there will be a direct ground connected to the test contact of the line, in the first instance the ground coming from the local first selector, such as the selector S, (Fig. 1), and in the latter instance from a connector, such as the connector C.

When the wipers of the connector are set on the contacts of the busy line, the busy relay of the connector operates in the usual manner and connects ground to the ring control conductor through the operating winding of the switching relay of the connector. This ground extending back over conductor 34, wiper 202′, contacts 245, and resistance 223, operates relay 210. Relay 210 prepares the releasing circuit, connects the upper terminal of relay 209 to the upper talking conductor by way of contacts 268 and 274, and opens a point in the original operating circuit of relay 209 at contacts 283. The switching relay of the connector does not operate at this time due to resistance 223 which reduces the current flow in the circuit. The test wiper of the connector is then connected to the talking conductor which extends back over conductor 32, wiper 201′, contacts 290, 274 and 268, to the upper terminal of relay 209. Since the line is assumed to be busy at the local connection, the test wiper will encounter direct ground, as previously stated, and relay 209 will be short-circuited. Relay 209 restores and connects up the local busy tone at contacts 272. The operator is informed by this tone that the wanted line is busy in a local connection and will then proceed to establish a talking connection therewith. To do this the operator dials an additional digit of any value, and relay 203 responds in the usual way as does relay 201. Relay 201 on operating connects relay 208 in parallel with relay 210 by way of contacts 233, 269 and 275. Relay 208 and the switching relay of the connectors operate in series over the above circuit. Relay 208 operates, completes a temporary locking circuit for itself at contacts 266, and opens the holding circuit of relay 205 at contacts 267. Relay 205 releases and closes the circuit of relay 204 which operates and switches the selector over to talking condition exactly as in the previously described connection.

The operator may now converse with the subscribers engaged in the local connection and inform them that a trunk call is waiting. The operator will then actuate the ringing key K1 of the dialling cord DC, thereby connecting high voltage battery to the control circuit to operate relay 207 of incoming selector ITS as before. Relay 207 completes a circuit from ground, contacts 262 and 277, lower winding of relay 211, to battery. Relay 211 is a two-step relay and closes its contacts 284 and 288 when energized over its lower winding alone, without opening any of the normally closed contacts. Ground is now connected to both talking conductors, one circuit extending from ground, contacts 262, 277, 284, 285, 279 and 234, conductor 370, upper-left-hand winding of repeating coil RC, conductor 367, contacts 298, 274 and 290, and wiper 201′. The other circuit extends from the same ground by way of contacts 286, 281 and 255, conductor 373, contact 321, lower-left-hand winding of repeating coil RC, conductor 374, and contacts 296, to wiper 204′. The ground on the two talking conductors is extended through the selector and connector, to the called line and unbalances the differential relay of the first selector engaged in the local call. This relay operates to initiate the release of the local connection, as previously described for selector S. The calling and called subscribers are now connected by way of the operator's cord circuit and the various switches whose operations have just been explained. Supervision and release is exactly the same, as in the previously described call to an idle line.

When a call such as has just been described is extended to a line busy in a toll connection, relay 210 will operate as before and completes a discriminating test circuit for relay 209. As previously stated, a line busy in a toll connection is marked by ground through a resistance on the test contact. This ground is not sufficient to shunt relay 209 and consequently relay 209 remains operated and the toll busy tone is connected to the calling line by way of contacts 271, 289 and 257. The operator will then release the con-

nection by removing the plug from the jack.

A toll connection is extended by the operator in exactly the same manner as the foregoing trunk connection. It may be mentioned, incidentally, that the metering apparatus and regenerating repeater do not function in calls of this type.

Referring now to the selector, Fig. 1, the operation for a trunk call has been explained and since the operation on local calls is substantially the same, it is not considered necessary to describe it in detail. It may be pointed out, however, that the selector is arranged to absorb one or more digits which adapts it for use in a multi-office system employing a universal numbering scheme. When the switch is operated to the critical level, normal post springs 116 close, and, when relay 107 restores shortly after the last impulse of the series, a circuit is closed from ground, through contacts 116 and 160, off-normal contacts 122 which closed on the first vertical step of the wipers, through the winding of release magnet 113 to battery. Magnet 113 operates to restore the wipers to normal in the usual way. It is obvious that should the critical level again be called the same operation will take place and the switch will restore to normal.

Referring now to the metering equipment shown in Figs. 5 and 6, the operation of the transfer circuit TT will be described. It will be recalled that the switches MT, CT and PT, were previously described as being common to the exchange and that for emergency service, a duplicate set of these switches is provided. The switches MT and CT of the duplicate set are identical with those of the regular set. The switch PT of the duplicate set is similar to that of the regular set with the addition of the starting apparatus ST. When the duplicate switch PT is not in use, the pendulum will be moved to the right and held in that position by the lug on the armature of relay 612. When the armature is actuated, the pendulum is released and vibrates in the usual manner.

It was previously described how the wipers 513 and 514 of the switch MT alternately close circuits for relays 602 and 603. These relays are slow-to-release and when operating normally, will open a point in the circuit of the dash-pot relay 606 at each step of the switch MT. Relay 606, incidentally, is provided with a plunger operating in a liquid filled cylinder which governs the speed of operation. The relay releases quickly, however, when its circuit is opened. Relay 606 may be adjusted to operate within any reasonable period, intervals of approximately twelve seconds being commonly used. If trouble develops in any of the regular timing switches while a call is in progress, the timing switch MT will remain on a particular set of contacts for a longer time than usual. Either relay 602 or relay 603 will, therefore, be energized continuously while the other relay will be in normal position, and a circuit will be closed for relay 606. After the predetermined interval, for example twelve seconds, relay 606 will close contacts 632 and 633, thereby closing circuits for relays 605 and 608. Relay 605 on operating will extend the ground from contacts 633, by way of contacts 629 and 645, through relay 612, to battery. Relay 612 will actuate its armature, release the pendulum, and permit contacts 645 to open and contacts 646 to close. The armature of relay 612 will then remain locked mechanically in this position until manually released, and relay 605 will lock up over contacts 646. Relay 605 will connect ground to alarm conductor 637 at contacts 626, close a circuit for relay 608 at contacts 627, and close an operating circuit for the duplicate pendulum timer at contacts 631. The duplicate timer, instead of having its pendulum connected to ground by way of jumper 647, is connected instead to the contacts 631 by a jumper 648. Relay 608 on operating extends ground from contacts 633 and 636 to alarm conductor 638. Relay 604 operates and transfers the various operating conductors from the regular master timer and cam timer to the corresponding duplicate switches by opening contacts 619, 621, 623 and 625, and closing contacts 618, 620, 622 and 624. The duplicate switches will now operate in exactly the same manner as the regular set previously described, and relays 602 and 603 will again be operated alternately by the duplicate master timer. The dash-pot relay will restore and open the alarm circuit over conductor 638 at contacts 633. Relay 605 will remain locked up as previously stated and an alarm signal will be operated by the ground on conductor 637. This alarm may be a lamp or bell or any other suitable signal that serves to call the attention of an operator or other person to the condition of the metering apparatus. Should trouble also develop in the duplicate apparatus while the same is in use, relay 606 will again operate and connect ground to conductor 638 to operate an emergency alarm indicating that both sets of metering switches are inoperative.

What is claimed is:

1. In an automatic telephone system, switching mechanism controlled by a calling subscriber for extending a connection to a called subscriber's line which may be either idle or busy, and means operative independent of control from the calling subscriber when a connection is extended to a line busy in another connection for signalling both subscribers and for releasing said other connection.

2. In an automatic telephone system, switching mechanism controlled by a calling subscriber for extending a connection to a

called subscriber's line which may be idle, busy in a local connection, or busy in a toll connection, means operative when a connection is extended to a line busy in a toll connection for signalling only the calling subscriber, and means automatically responsive when a connection is extended to a line busy in a local connection for signalling both the calling and called subscribers.

3. In an automatic telephone system, switching mechanism controlled by a calling subscriber for extending a connection to a called subscriber's line which may be idle, busy in a local connection, or busy in a toll connection, means operative when a connection is extended to a line busy in a toll connection for returning a busy signal to the calling subscriber, and means automatically operative responsive to the extension of a connection to a line busy in a local connection for momentarily transmitting a busy tone to both the calling and called subscribers and for then releasing said local connection.

4. In a telephone system, calling lines and called lines, automatic switches including an impulse repeater for extending connections between said lines, and means in the repeater automatically operated responsive to the extension of a call to a line engaged in another connection for interrupting said other connection and for establishing a new connection.

5. In a telephone system, calling lines and called lines, automatic switches including an impulse repeater for extending connections between said lines, means responsive to the extension of a call to a line engaged in another connection for causing both the lines engaged in said other connection and the calling line to be signalled, and means in the repeater automatically operated responsive to said connection for causing the release of said other connection.

6. In a telephone system, a line which may be idle or busy, automatic switches operated responsive to dialled digits corresponding to the numerical designation of the line for extending a connection to the line regardless of its idle or busy condition, means in one of said switches automatically operative when the line is busy in another connection for applying a characteristic tone thereto, and means in said one switch controlled by automatically operated means in a preceding switch for releasing said other connection.

7. In a telephone system, a trunk line terminating in a repeater, a connector switch, means for extending a connection over said trunk line to a called line via said repeater and said connector, and means in said repeater automatically operative responsive to the extension of a connection to a line busy in another connection for causing said connector to release said other connection and to establish said trunk connection.

8. In a telephone system, a trunk line terminating in a repeater, a connector switch, means for extending a connection over said trunk line to a called line via said repeater and said connector, means in said repeater operative responsive to the extension of a connection to a line busy in another connection for causing said connector to release such connection, and means in the connector for applying a warning tone to said other connection prior to its release.

9. In a telephone system, a trunk line terminating in a repeater, a connector switch, means for extending a connection over said trunk line to a called line via said repeater and said connector, means in said repeater responsive to the extension of a connection to a line busy in another connection for causing said connector to release said other connection, and means in said connector for applying a characteristic tone to both the trunk line and to said other connection prior to the release of such connection.

10. In a telephone system, a trunk line terminating at each end in a repeater, an impulse regenerating device adapted to be temporarily associated with one of said repeaters, means for seizing said one repeater and for transmitting impulses thereto, means for registering said impulses in said device, means in said device for transmitting corresponding impulses over the trunk line to the other repeater, and means in said other repeater for repeating the impulses to switches associated therewith.

11. In a telephone system, two exchanges, switches in one exchange adapted to be directively controlled over two conductors of a trunk in series, switches in the other exchange adapted to be directively controlled over one conductor of a trunk and a ground return, a trunk line connecting said exchanges, means at the first exchange for seizing the trunk line and for transmitting directive impulses thereto, a register sender associated with the trunk line at said one office for registering said impulses and for transmitting corresponding impulses over the trunk line to the other exchange, and a repeater at the other exchange for repeating said impulses to the switches in that exchange.

12. In a telephone system, two exchanges connected by a trunk line, automatic switching apparatus in each exchange adapted to operate according to different pulse ratios, and a register sender in one exchange adapted to respond to impulses having the pulse ratio required by the apparatus of that exchange and to retransmit corresponding impulses over the trunk line to operate the apparatus in the other exchange, said retransmitted impulses having the pulse ratio required by the apparatus of the other exchange.

13. In a telephone system, a composited trunk line, means for seizing the trunk line

at one end, a register sender temporarily associated with said one end of the trunk line, means for transmitting directive impulses to said register sender, means in the register sender for transmitting corresponding impulses over the dial leg of the trunk line directly, and a repeater at the other end of the trunk line for repeating said impulses to automatic switches.

14. In a telephone system, a composited trunk line, a branch at one end of the trunk line accessible to automatic switches, a second branch at said one end adapted to be temporarily connected with a register sender, branch at the other end of the trunk line terminating in an automatic switch, and a second branch at said other end terminating in an operator's position.

15. In a telephone system, a composited trunk line, a branch at one end of the trunk line accessible to automatic switches, a second branch at said one end adapted to be temporarily connected with a register sender, and means responsive to the seizure of said first branch by a switch for extending a conductor of that branch to registering apparatus via a conductor of the second branch and for connectisg the dial leg of the trunk line directly to sending apparatus via another conductor of the second branch.

16. A call timing device comprising a continuously operating interrupter, a rotary switch adapted to operate under control of said interrupter during the course of a call for successively connecting a potential to a series of contacts, and a second rotary switch adapted to operate responsive to the answering of the call for connecting with the contact to which the potential is connected at that particular instant.

17. In a telephone system, a continuously operating timing switch adapted to transmit metering impulses from successive positions, a calling line, and means associated with said line for selecting the particular position of said switch from which metering impulses will be transmitted over the line.

18. In a telephone system, a plurality of lines, a continuously operating common timing switch adapted to momentarily and successively connect a potential to each of a plurality of contacts, and means associated with each line for selecting the particular contact to which a potential is connected at the instant a call over the associated line is answered.

19. In a telephone system, a plurality of lines, a meter for each line, a continuously operating common timing switch adapted to connect a potential to each of a plurality of contacts at regular intervals, means associated with each line for selecting the particular contact to which a potential is connected at the instant a call over the associated line is answered to operate the meter of that line, and means controlled by said switch for reoperating said meter after a predetermined time.

20. In a telephone system, trunk lines, a switch associated with each trunk line, a common switch, sets of contacts accessible to each switch, multiple connections between corresponding contacts of each set, means for operating said common switch under control of said interrupter to engage successive contacts of the accessible set when a call is in progress on any of said trunk lines, and means responsive when a call is answered for operating the switch associated with the calling trunk line to connect with a contact corresponding to the one engaged by said common switch at that particular instant.

21. In a telephone system, a trunk line and means for extending a call thereover, a meter controlling relay for the trunk line, a switch associated with the trunk line, contacts accessible to said switch, a timing device adapted to operate continuously while a call is in progress for momentarily connecting a potential to said contacts successively, means responsive when the call is answered for operating said switch to engage the contact to which a potential is connected at that particular instant whereby said relay is operated momentarily, means responsive when a potential is connected to the engaged contact a second time for reoperating said relay momentarily, and means responsive when a potential is connected to the engaged contact a third time for interrupting the call.

22. In a telephone system, a trunk line, a relay for the trunk line adapted when operated to connect a characteristic potential to a conductor thereof, a switch associated with the trunk line, three wipers for said switch, a timing device, means for extending a call over the trunk line, means responsive when the call is answered for operating said switch to connect with said device, means controlled by said device over the first and second wipers of said switch for operating said relay, means controlled by said device over the third wiper of said switch for applying a tone to the trunk line, and means controlled by said device over the first wiper of said switch for interrupting the call.

23. In a telephone system, a line and a meter associated therewith, a control switch, three wipers for the switch, a timing device, means for extending a call over the line, means responsive when the call is answered for operating said switch to connect with said device, means controlled initially by said device over the first and second wipers for operating said meter, means controlled by said device over the third wiper for applying a tone to the line, and means controlled subsequently by the device over the first wiper for interrupting the call.

24. In a telephone system, a subscriber's line and a meter associated therewith, a meter controlling device, an operator's position, means for extending a connection from the line to said position, means at the position for further extending the connection, and means controlled by the operator for rendering said device effective to operate said meter at intervals during the course of the connection and to release the connection after a predetermined time.

25. In a telephone system, a subscriber's line and a meter associated therewith, a meter controlling device, means for extending a call from the line, means for answering the call, and means responsive to the answering of the call for rendering said device effective to operate said meter at intervals during the course of the call, to apply a warning tone to the line, and to interrupt the call after a predetermined time.

26. In a telephone system, a combination local and toll connector, a repeater, means for operating said connector to extend connections to called lines, means in the connector effective when a connection is extended to a line busy in another connection and operated under control of a toll operator for causing the connector to interrupt said other connection, and means in the repeater effective when a connection is extended through the repeater and connector to a line busy in another connection and operated independent of control by the calling party for causing the connector to interrupt said other connection.

27. In a telephone system, a combination local and toll connector, a repeater, means for operating the connector to extend connections to called lines, means in the connector effective when a connection is extended to a line busy in another connection and operated under control of a toll operator for causing the connector to interrupt said other connection, and means in the repeater effective when a connection is extended through the repeater and said connector to a line busy in another connection and operated responsive to the establishment of said connection for causing the connector to interrupt said other connection.

28. In a telephone system, a trunk line connecting two exchanges, a register-sender associated with the trunk line at one exchange, a repeater terminating the trunk line at the other exchange, an auxiliary switch associated with said repeater, a branch trunk extending from the repeater to an automatic switch, a second branch trunk extending from the repeater to an operator's position, means including said register sender for transmitting impulses over the trunk line to extend a connection, means in the repeater for repeating the impulses to said auxiliary switch to set the same and for repeating impulses over said first branch trunk to directively operate said automatic switch, and means controlled by said auxiliary switch for releasing said automatic switch and for extending the connection to said operator's position via said second branch trunk.

29. The combination with a continuously operating switch adapted to successively engage contacts of a contact bank, of a plurality of hunting switches having access to contacts multipled with corresponding contacts engaged by said first switch, means for taking said hunting switches into use, and means responsive to one of said hunting switches being taken into use for operating the switch to connect with the particular contact multiply connected with the contact engaged by said first switch at the time said one switch is taken into use.

30. In combination, a plurality of rotary switches, multiply connected bank contacts for said switches, a continuously operating interrupter, means including said interrupter for operating one of said switches to engage successive contacts of its bank, and means individual to each of said other switches for operating the switches to connect with a contact multipled to the contact engaged by said one switch.

31. The combination with a group of rotary switches, of a set of bank contacts for each switch, a timing device comprising a rotary switch and a continuously operating interrupter, a set of bank contacts for said last switch, multiple connections between corresponding contacts of all of said contact banks, means including said interrupter for operating said last switch to apply a potential to successive contacts of its associated contact bank, and means for operating any of said first switches to engage a multiply connected contact marked by said last switch at any particular instant.

32. The combination with a group of rotary switches adapted to be associated individually with calling lines, of a set of bank contacts for each of said switches, a timing switch, a set of bank contacts for said timing switch, a continuously operating interrupter, circuit connections controlled by said interrupter for operating said timing switch to mark successive contacts in its associated contact bank, and multiple connections between contacts of the bank of said timing switch and corresponding contacts of the banks of said rotary switches.

33. The combination with a group of rotary switches adapted to be associated individually with calling lines, of a set of bank contacts for each of said switches, of two timing switches, a set of bank contacts for each timing switch, multiple connections between contacts of the timing switch banks and corresponding contacts of the rotary switch banks, means normally effective for

operating one of said timing switches to mark successive contacts in its associated bank, and means effective responsive to the failure of said one timing switch to operate properly for operating the other of said timing switches to mark successive contacts in its associated bank.

34. In an elapsed time metering system, meter current pick-up switches adapted to be associated individually with calling lines, two master timing switches adapted when operated to apply metering current to the bank contacts of said pick-up switches at predetermined intervals, means normally effective for operating one of said timing switches, and means responsive to the failure of said one timing switch to operate properly for operating the other of said timing switches.

35. In a telephone system, a plurality of lines, a meter for each line, a common timing switch operating continuously through a plurality of positions, and means associated with each line for determining the particular positions in which said timing switch is effective to operate the meters of the respective lines.

36. In a telephone system, a plurality of lines, a meter for each line, a common timing switch operating continuously through a plurality of positions, a pick-up switch associated with each line, and means including the pick-up switch of a line for rendering said timing switch effective to operate the meter of the line when the timing switch reaches a particular one of said positions.

37. In a telephone system, a plurality of lines, a meter for each line, a common timing switch operating continuously through a plurality of positions, a pick-up switch associated with each line, means for extending a call over one of said lines, means for answering the call, and means including the pick-up switch of the line for adapting the timing switch to operate the meter of the line each time the said timing switch reaches the position which it occupied at the instant the call was answered.

38. In a telephone system in which local connections between subscribers of the system are established over directively controlled switching apparatus and in which calls from other systems to said subscribers are established over a part of said apparatus by an operator, means in the common portion of the apparatus for enabling an operator to establish connections with engaged subscribers at will, and means in the portion of the apparatus used for local connections for automatically controlling said last means.

39. In a telephone system in which local connections between subscribers of the system are established over directly controlled switching apparatus and in which calls from other systems to said subscribers are established over a part of said apparatus by an operator, means in the common portion of the apparatus for enabling an operator to establish a connection with a subscriber engaged in a prior connection and to release said prior connection at will, and means in the portion of the apparatus used for local calls for automatically controlling said last means.

40. In a telephone system, a line, a registering device associated with the line, a control device, means for extending a call from the line, means for associating said control device with the line during the call, means for answering the call, and means responsive to the answering of the call for rendering said control device effective to operate said registering device at predetermined intervals throughout the call, to transmit a signal over the line after the call has lasted a predetermined time, and to interrupt the call following the transmission of said signal.

In witness whereof, I hereunto subscribe my name this 24th day of February, A. D. 1930.

JOHN WICKS.

In witness whereof, I hereunto subscribe my name this 17th day of February, A. D. 1930.

ROY F. GOULD.